# THE MULTIPLEX PRINTING TELEGRAPH SYSTEM

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# THE WESTERN UNION TELEGRAPH COMPANY

SPECIFICATIONS

FOR

## THE MULTIPLEX PRINTING TELEGRAPH SYSTEM

THEORY AND OPERATION

Section 1. General Theory
Section 2. The Distributor and Its Associated Apparatus.
Section 3. Transmitter 1-A.
Section 4. Perforator 1-A.
Section 4A. Perforator 2-A.
Section 5. Printer 1-A.
Section 5A. Printer 5-A.
Section 5B. Printer 3-A.
Section 5C. Printer 3-B.
Section 6. Auto Control 1-A.
Section 7. Terminal Set Assembly.
Section 8. Test and School Sets.

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## MULTIPLEX SPECIFICATIONS

These specifications are issued primarily for the use of testing and regulating forces assigned to the care and operation of Multiplex equipment.

A knowledge of the fundamental principles of electricity and magnetism and an understanding of the operation of the duplex are necessary for the proper understanding of the theory and operation of the apparatus described.

Those not already familiar with these subjects are advised to first study some standard work on Principles of Electricity and Magnetism, also one of the many books which take up the development of Duplex Telegraphy. This will enable them to obtain a much better understanding of the operation of the Multiplex System.

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# MULTIPLEX SPECIFICATIONS

## INTRODUCTION:

1. Every system of telegraphy, no matter what method employed, has for its object the exchange of signals between two points of communication.

2. In the common types of electric telegraphs an electric current controlled by the sending station is made to operate the armature of an electromagnet at the receiving station. The armature of the electromagnet, in turn, produces an audible or visible signal which may be "read" by the receiving operator.

3. In the Multiplex System described in these specifications the sending operator controls the current in the telegraph line by means of an automatic transmitter, thereby sending to the line signals which operate electromagnets at the receiving station. These electromagnets operate an automatic receiver or typewriter which translates and writes the signal in the form of Roman characters.

4. The system provides also for increasing the output of the telegraph wire by distributing the use of the line successively to one or more of the automatic transmitters and receivers for equal periods of time, thus establishing one or more "channels," each of which operates as an independent telegraph line.

5. The basis of the system is:

I. A duplexed telegraph line by means of which simultaneous transmission in both directions is obtained.

II. One or more automatic transmitters at each end of the line by means of which combinations of five impulses representing letters and other functions may be properly set up for transmission to the line.

III. One or more electrically operated printers at each end of the line for the translation and printing of the combinations of the five impulses sent to them from the telegraph line.

IV. One or more distributors at each end of the line so operated that the brushes of a distributor at one end of the line rotate in synchronism and in phase with the brushes of another distributor at the other end of the line. By means of these distributors the combinations of five positive and negative impulses per character or letter set up by the transmitters are sent to the line in their proper sequence and redistributed, also in proper sequence, to printers for translation and printing, at the other end of the line.

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 1

THEORY

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## GENERAL THEORY

1. The Duplex is an integral part of the Multiplex System. A review of the duplex theory may therefore be beneficial before taking up the new features of the Multiplex itself.

2. The use of duplex telegraph apparatus makes possible the simultaneous transmission of two messages, one in each direction, over one wire.

3. To accomplish this the apparatus should fulfill the following conditions:

(a) The receiving instruments at both stations must remain in the circuit all the time, ready to respond to signals from the distant station.

(b) The receiving instrument at each station must not respond to any signals made on the sending key at that station.

4. One of the best ways to meet both of these conditions is by the use of differential relays, and the resultant system is termed the differential duplex.

5. In a differential relay there are two magnet windings. If currents are passed through the two windings in the same direction, they assist each other in developing magnetism and thus attracting the relay armature.

Currents may, however, be passed through the two windings in opposite directions, in which case the resultant magnetic effect, or pull upon the relay armature, will correspond to the difference between the strengths of the two currents; hence the name differential. If the two opposing currents are of exactly the same strength, their magnetic effects will neutralize each other, and they will cause no pull on the armature.

6. In Figure 1 a very simple differential relay is shown. One of its windings carries a current of 60 milliamperes, and the other winding 30 milliamperes. As the currents pass around the core of the electromagnet in opposite directions, the net result is the same as if one of the windings had been energized with a current of 30 milliamperes and the other winding left open. The armature is therefore attracted with a force due to

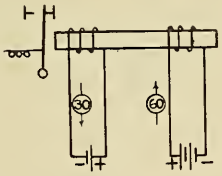


Fig. 1

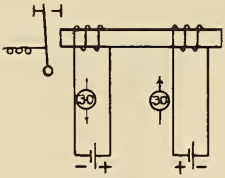


Fig. 2

the 30 milliamperes, or the difference between the currents in the two windings. In Figure 2 the same relay is shown, with a current of 30 milliamperes in each of the two windings. The difference between the two currents is evidently zero, and the magnetic effect is likewise nothing, with the result that the armature is not attracted.

7. The simplest form of differential duplex circuit is illustrated in Figure 3. A line wire of 1550 ohms resistance is shown between the "home" and "distant" stations. At each station a differential relay of the type represented in Figure 1 is used, with two windings having a resistance of 400 ohms each. One of these windings is connected to the line wire, while the other is connected to ground through a resistance AL of 2090 ohms. The remaining ends of both windings are joined together and the junction apex or "split" point (as it is often called) connected to the lever of a 3-point key for signaling. With the keys at both stations at rest; i. e., in the "spacing" position, as shown, the circuit is connected to ground through a resistance of 150 ohms at each station. No current

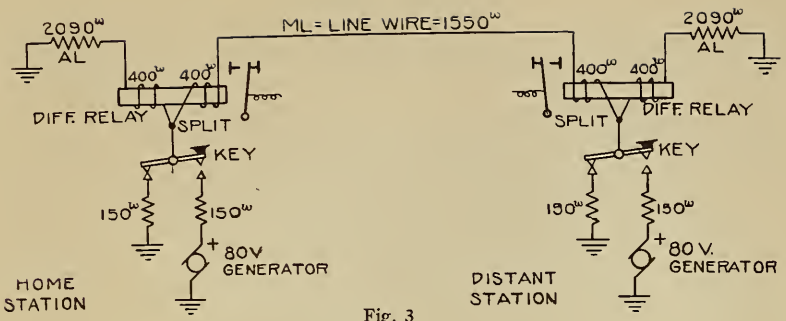


Fig. 3

is flowing through any of the branches of the circuit and the relay armatures therefore rest on their back stops or spacing contacts at both stations.

8. If, in order to make a dot or dash signal, the key at the home station is now depressed to its "marking" position, the apex at that station is connected, through a 150-ohm resistance, to the 80-volt generator. As shown in Figure 4, a current of about 57 milliamperes is drawn from the generator, and divides into two equal parts at the apex, 28.5 milliamperes passing through each of the two windings of the home relay; as in the case of Figure 2, the currents through the two windings neutralize each other, and the relay armature remains on its spacing stop; i. e., the home relay is entirely unaffected by the transmission of the signal from the home station to the distant station. The distant relay, however, responds to the signal, for a current of 28.5 milliamperes flows through one of its windings, and a current of 1.5 milliamperes through the other winding.

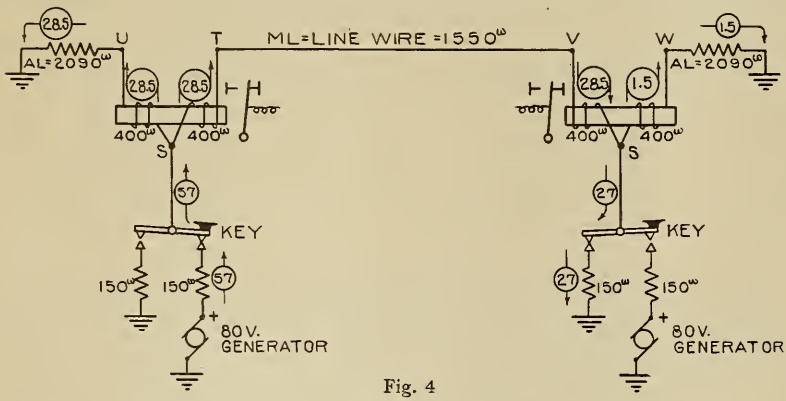


Fig. 4

Both currents are in the same direction, and therefore assist each other in pulling over the relay armature to its marking position with a force corresponding to that obtainable by sending 30 milliamperes through either winding alone. Similarly, signals sent on the distant key would operate the home relay without in any way affecting the distant relay. The means by which this result has been obtained must be clearly kept in mind; we have caused the outgoing current to divide equally between the two windings of the relay at the transmitting station, by making the extensions connected to these windings of

equal resistance; that is, by making the resistance of the branch AL (Fig. 4) exactly the same as that of the line wire ML (1550 ohms) plus that of the distant apparatus from the point marked V to ground (540 ohms), or a total of 2090 ohms in each case. If the branch AL were of either lower or higher resistance than the line wire ML and the distant apparatus, more current would flow through one winding than through the other winding of the home relay, thus tending to cause that relay to respond to the signals made on the home key.

9. So far we have considered two working conditions of the duplex, as follows: (1) the case of spacing signals being sent from both stations; that is, both the home and distant keys at rest, as per Figure 3; (2) the case of a marking signal; i. e., a dot or a dash, being sent from one station and a spacing signal from the other, as per Figure 4. The only remaining condition to be considered is that of marking signals being sent

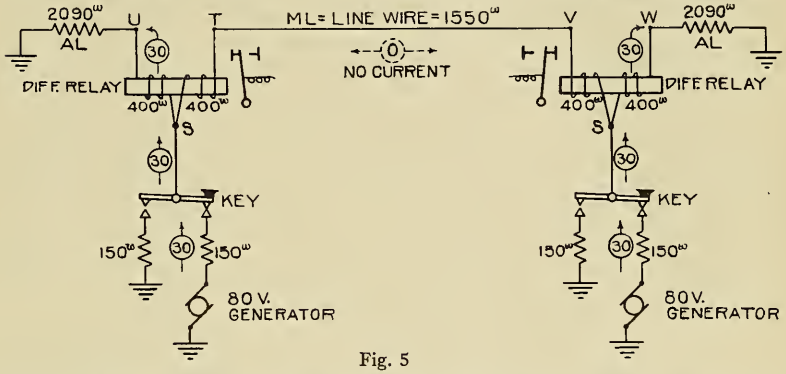


Fig. 5

from both stations; that is, both the home and distant keys depressed. This is illustrated in Figure 5. As the voltages of the two generators are equal and of the same polarity, and as the resistances in the circuit are equal at both ends, the tendencies of the currents to flow out over the line via the points T and V are exactly the same, and counterbalance each other, with the result that no current flows in the line wire ML. A current of 30 milliamperes will, however, flow through one winding of each relay, as shown; this current in the relay at each station being drawn from its own generator, and passing through the branch AL in each case. It may appear at first sight that this condition is not in accordance with the fundamental principle outlined in Paragraph 3 (b), viz., that the receiving instrument at a station must not respond to any signals made on the sending key at that station. A little reflection will, however, show that although no part of this current in either relay actually comes over the line wire, the current operating the relay in each case is produced by the generator at that station in response to the signal which is being made on the key at the other end of the circuit. That this is so can be demonstrated by releasing either key, when the magnetic effect in the distant relay will immediately cease, and the circuit conditions will then be similar to those shown in Figure 4. The release of the key will not affect the relay at its own station, and therefore the condition stated in Paragraph 3 (b) is fulfilled.

10. It is therefore apparent that with the arrangements described above, two messages may be simultaneously transmitted, in opposite directions, over one wire. In fact the "Single Current Differential Duplex," as this scheme of connections is termed, and particularly a slightly modified form of it known as the "Stearns Duplex," is capable of giving fairly good duplex service under favorable conditions.

11. In actual practice, however, there are many conditions under which the efficiency of the single-current duplex is greatly reduced. Very much better results can be obtained by the double-current system, which is therefore almost exclusively used. In

this system, as described in the following pages, each marking signal (a dot or a dash) is made by sending out a negative current, and each spacing signal by sending out a positive current. It is evident that the receiving instrument in this case must be one in which the movements of the armature depend on the direction of the current passing through the coils. Such an instrument is the polar relay, which is so constructed that a current flowing through it in one direction will tend to move the armature to the right, and when the current is reversed the armature will tend to move to the left. If the armature be already on the side toward which a current of a certain direction tends to move it, there is, of course, no actual movement of the armature, and it remains banked tightly against the stop at that side.

12. The balancing scheme of the double-current duplex is the same as that of the single-current duplex; that is, an artificial line (AL in Figures 3, 4 and 5) at each station is adjusted to equal the resistance of the real line and the apparatus at the distant station. By having the polar relays equipped with differential windings, and using connections similar to those already described, the artificial line at each station permits signals to be sent out from that station without affecting the relay there. In the double-current system, however, the current in the artificial line does not, as in the single-current system, neutralize the magnetic effect, due to the main line current in the relay at that station when the distant key is in the spacing position. This will become evident when it is remembered that in the single-current system the spacing position of the key connected the circuit to ground and removed the source of current, while in the double-current system the spacing position of the key connects the circuit to a source of current equal to that used for the marking signal, but opposite in direction. The function of the artificial line in this case, therefore, is to prevent the operation of the key at the same station causing any alteration in the amount or direction of the current in the relay. How it accomplishes this may be understood by an examination of Figures 6, 7, 8 and 9. These theoretical diagrams show a simplified double-current differential duplex circuit connecting two stations, named Nevada and Wyoming.

13. Figure 6 shows the conditions existing when the key is in the spacing position at Nevada, thus sending out a positive current from the generator $D_2$; at Wyoming the key is closed for sending a marking signal, thus connecting the circuit to the negative generator at that point. Current flows, therefore, over the circuit from Nevada to Wyoming, and divides between the branches at each end as per the diagram. It will be seen that the differential polar relay at each station has a current of 57 milliamperes in one winding and 27 milliamperes in the other. The control of the armature, in each case, is due to the magnetic effect of the difference between these values; that is, 30 milliamperes. At Nevada the heavier current is flowing from the apex S to the line

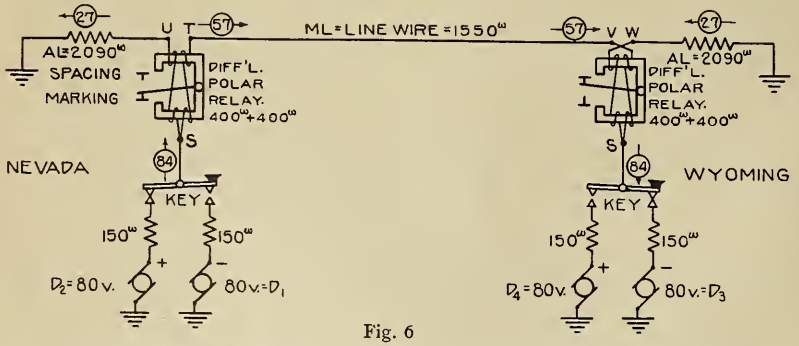


Fig. 6

wire ML (point T), thus holding the armature on its marking contact: at Wyoming the corresponding current is from the line wire (point V) to the apex, thus causing the opposite effect of holding the armature on its spacing stop or contact. These positions

of the relay armatures, it will be noted, correspond in each case with the position of the distant key.

14. If the key at Nevada is now depressed to send out a marking signal, the conditions will be as shown in Figure 7; as both ends of the circuit are connected to generators of the same polarity and potential (80 volts negative), there is an equal tendency for current to flow to line via the point T as via the point V, and because these tendencies counterbalance each other, no current flows over the line wire ML. A current of 30 milliamperes, however, flows through that winding of the polar relay which connects with the artificial line at each station. At Nevada this current flows from the point U to the apex S, thus continuing the same magnetic conditions there as in Figure 6, and holding the armature on its marking contact; at Wyoming the flow is now from point W to the apex, giving the opposite magnetic effect to that shown at Wyoming in Figure 6, and in response to this change the armature has moved to its marking contact, corresponding to the position of the Nevada key. Each relay is therefore responding to the signal being sent on the distant key, although the current passing through each relay comes entirely from a generator at its own station; for a change in the position of the key at either station will reverse the current through the relay at the distant station, bringing about the conditions shown either in Figure 6 or Figure 8.

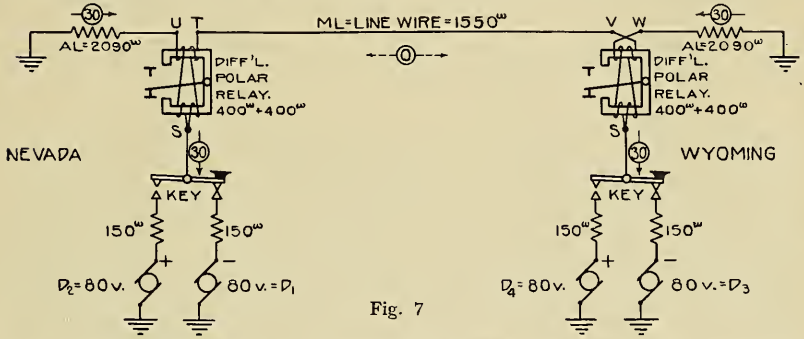


Fig. 7

15. Suppose the operator at Wyoming "opens" his key; i. e., releases it to the spacing position. This connects his end of the circuit to the positive generator $D_4$, and current flows over the line from Wyoming to Nevada. This results, as shown in Figure 8, in reversing the current through the polar relay at Nevada, throwing its armature to the spacing position. The polar relay at Wyoming is, of course, unaffected, and continues to give a marking signal in response to the depressed key at Nevada.

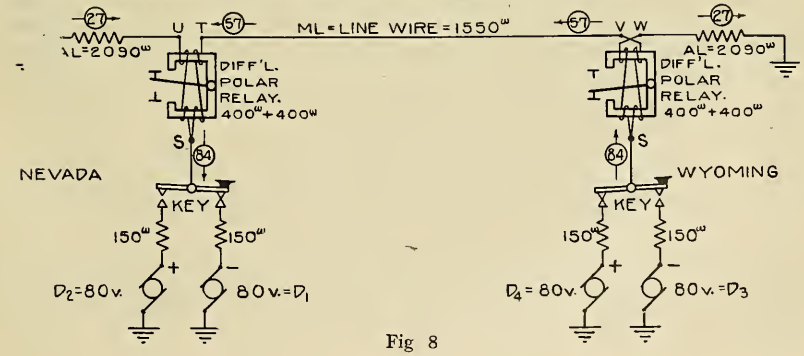


Fig 8

16. In Figure 9 is shown the current distribution when the keys at both stations are in the spacing position. The conditions then differ from those shown in Figure 7 only in the direction of the current through the various branches. The relay at each station is operated by a current flowing from the apex through one of the windings to the artificial line (i. e., to point U or to point W), thus keeping the armature in its spacing position in both cases.

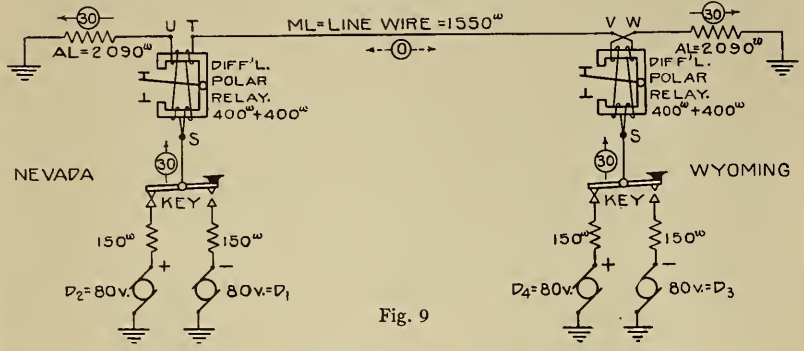


Fig. 9

17. So far it has been assumed that it merely is necessary for the artificial line at each station to have a resistance equal to that of the main line plus the apparatus at the distant station. This is seldom, if ever, the whole truth. Every line wire, in addition to its current-carrying qualities, is able to hold upon itself a quantity of electricity in the form of a stationary electric charge. This quality is known as the electrostatic capacity of the wire, and manifests itself by a tendency to delay the travel of the current over the wire, because the wire must become fully charged with electricity before the full strength of the current can reach the distant end. It also permits a rush of electricity into the wire at the beginning of each positive current to assist in the charging mentioned above, and at the beginning of each negative current the same quantity of electricity rushes out of the wire. These charging and discharging effects must be reproduced in the artificial line, so as to resemble as nearly as possible those occurring in the main line as described above. This is accomplished by the addition of adjustable condensers to each artificial line, by means of which the latter can be given an electrostatic capacity corresponding to that of the main line. Each condenser used for this purpose consists essentially of two conductors of such form as to have very large superficial areas, separated from each other by a very thin insulating material. The two conductors usually are of tinfoil, the insulator being paraffined paper. By rolling or piling up a large number of sheets of these substances in the proper order, and connecting together the alternate sheets of tinfoil to form the two terminals of the condenser, it is possible to build up in a small box a capacity equal to that of many miles of line wire. The condensers connected to the artificial line must not only accumulate a quantity of electricity corresponding to the static charge of the main line, but must accept this charge at the same rate as the similar charge passes into the main line, and in discharging must also act in unison with the main line capacity. To ensure this, each of the two or three condensers of the artificial line is connected to it through an adjustable resistance, generally termed a "retarding" or "timing" resistance. By varying these resistances the speed with which the condensers are charged and discharged can be regulated to correspond with line conditions.

18. It is necessary, of course, to apply a local circuit containing a sounder or some other device for producing an audible or visible signal to the contacts of each of the polar relays shown in Figures 6, 7, 8 and 9 in order that the receiving operator may read the signals.

## ELEMENTARY MULTIPLEX THEORY.

**19.** Before taking up the description of the apparatus employed in the Multiplex System, it is necessary to understand clearly the essential requirements that must be met in building up a system of printing telegraphy, and some of the means employed to meet these requirements.

**20.** In practically every system of electromagnetic telegraphy some form of switch or key is used to connect an electric potential to the line. This causes the armature of an electromagnet at the other end of the line to respond, which in turn produces the signal. The characters which represent the letters of the alphabet, etc., are made up of a number of these signals.

**21.** In the Multiplex System five keys and five electromagnets are used in combination for making each character.

**22.** Let us consider an arrangement such as shown in Figure 10. Here we have five keys connected to a common grounded source of electric current and also to five telegraph lines which are connected at the other end to five electromagnets, these being in turn connected to ground.

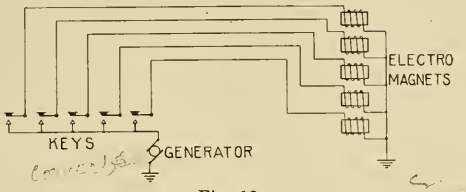


Fig. 10

**23.** By depressing one or more keys, any one or more of the electromagnets may be operated. In this manner it is possible to make all the combinations shown in Figure 11. To make the letter A, electromagnets 1 and 2 are energized by closing keys 1 and 2; to make the letter B, electromagnets 1, 4 and 5 are energized, etc.

| UPPER CASE | — | ? | : | $ | 3 | CITY | & | £ | 8 | BELL | ( | ) | . | , | 9 | 0 | 1 | 4 | THRU | 5 | 7 | ; | 2 | / | 6 | " | CAR. RET. | LINE FEED | LTRS. | FIGS. | SPACE |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| LOWER CASE | A | B | C | D | E | F | G | H | I | J | K | L | M | N | O | P | Q | R | S | T | U | V | W | X | Y | Z | | | | | |
| | 1 | 1 | | 1 | 1 | 1 | | | | 1 | 1 | | | | | | 1 | | 1 | | 1 | | 1 | 1 | 1 | 1 | | | 1 | 1 | |
| | 2 | | 2 | | | | 2 | | 2 | 2 | 2 | 2 | | | | 2 | 2 | 2 | | | 2 | 2 | 2 | | | | | | 2 | 2 | 2 | |
| | | | 3 | | | 3 | | 3 | 3 | | 3 | | 3 | 3 | | 3 | 3 | | 3 | | 3 | 3 | | 3 | 3 | | | | | 3 | | 3 |
| | | 4 | 4 | 4 | | 4 | 4 | | | 4 | 4 | | 4 | 4 | 4 | | | 4 | | | | 4 | | 4 | | | 4 | | 4 | 4 | |
| | | 5 | | | | | 5 | 5 | | | | 5 | 5 | | 5 | 5 | 5 | | | 5 | | 5 | 5 | 5 | 5 | 5 | | | 5 | 5 | |

Fig. 11

**24.** It is not practical to use five line conductors for the operation of the five electromagnets, for such a method would be wasteful of lines. The same results are accomplished in a different manner by making use of the arrangement shown in Figure 12.

**25.** The left hand figure represents the sending station, the right hand figure the receiving station. At each end is shown a distributor consisting of two concentric metallic rings, which are insulated from each other, the outer one being divided into six segments, which also are insulated from each other. Brush arms carrying sending and receiving brushes respectively are represented as rotating in synchronism with each other. Thus

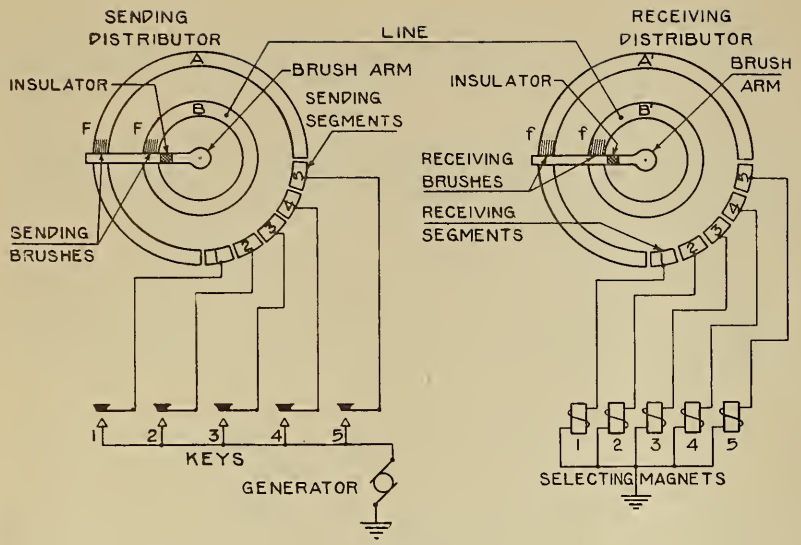


Fig. 12

the two arms are not only rotating at the same number of revolutions per minute, but they hold the same relative position at all times, so that if the sending brush is in contact with the sending segment 1 the receiving brush is in contact with receiving segment 1, and so on. The sending segments are connected as shown with the key levers, the contacts of which are connected to a battery or generator, the other pole of which is grounded. The receiving segments are connected to electromagnets, the other terminals of which are connected to ground.

26. Now we see that if we depress any one or all of the key levers at the sending station, and hold them in the depressed position until the brush has passed over their corresponding segments, the current that we connect to the line will flow through the keys and distributor at the sending station to the line, and thence through the distributor at the receiving station to the electromagnets corresponding to the depressed key levers and thence to ground. We have therefore operated the desired electromagnets as in the arrangement where we had five line wires, except that now we cannot operate them all at the same instant; each key and each electromagnet is connected to the line for a portion of the total time only, but this portion is made of sufficient duration to give the magnet ample time to operate.

27. The diagram in Figure 12 shows only one-fourth of the rings cut into small segments, but it is clearly seen that there is nothing to prevent us from making use of the whole circumference in the same manner as with the sections 1 to 5. By doing so we may obtain four groups of five sending keys and four groups of five receiving magnets. Each group of sending keys and their associated group of receiving magnets represent one Multiplex channel, each one being capable of transmitting and receiving one of the combinations shown in Figure 11 for each revolution of the brush arm.

28. In practice the sending and receiving of the Multiplex signals is not so simple as that just described. It would be impractical to transmit direct from the selecting keys to the selecting magnets. Also in order to take advantage of the polar duplex,

positive and negative impulses must be transmitted, and in order to get an impulse stronger than the line impulse to operate the selecting magnets, relays must be used. To incorporate these features in our theoretical system, therefore, we must modify Figure 12 as shown in Figure 13.

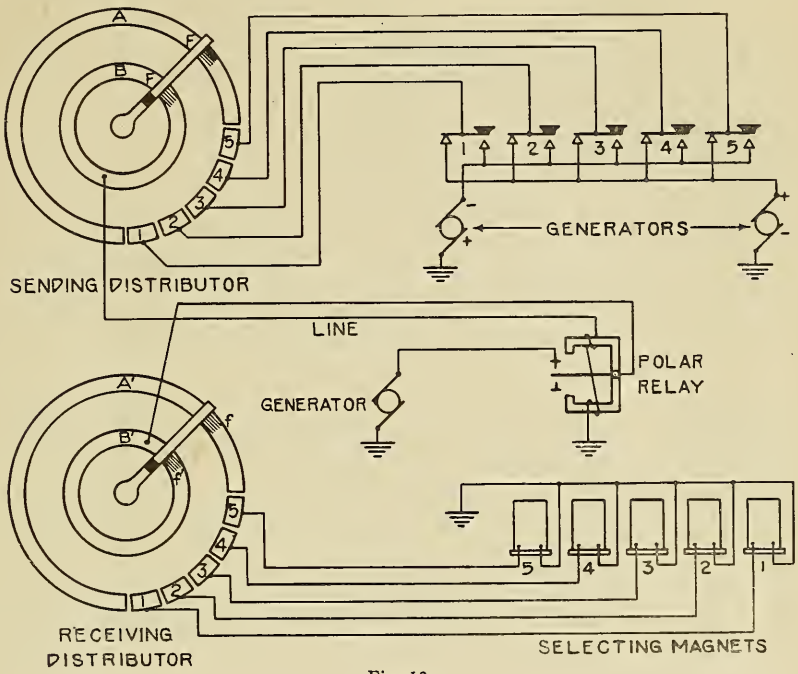


Fig. 13

**29.** Here we have all the essential features necessary for the operation of a Multiplex system over a duplexed line. It is necessary to provide only the duplex equipment, and provide both a sending and a receiving set at each station. To do this we must put two additional rings on our distributor and connect the two sets to our duplex line. We then have a set as shown in Figure 14, where only one of the two terminals is shown.

**30.** S and S′ represent the sending brushes, which are electrically connected; R and R′ the receiving brushes, which also are electrically connected with each other, but insulated from S and S′. For convenience in drawing and construction the two sets of brushes are placed at right angles to each other but the two groups are rigidly connected and rotate together.

**31.** With a system such as shown in Figure 14 one combination or letter may be sent and one received simultaneously for each revolution of the brush arms. As already stated we may connect more than one of these groups or channels to the distributor rings until we have divided the entire ring into segments, every five new segments constituting an additional channel.

**32.** One or more of such channels operated over a duplex line constitutes the essential features of the Multiplex system.

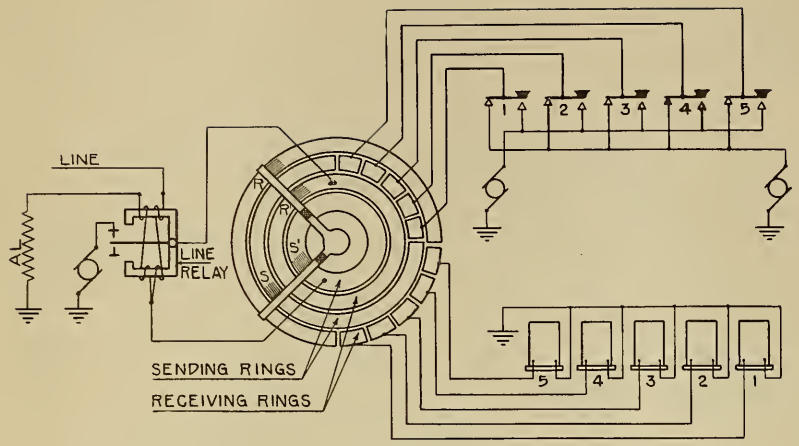


Fig. 14

33. Thus far we have not mentioned the manner in which the sending keys are operated, neither have we said anything about the way in which the five selecting magnets serve to translate the five received impulses into the letter or function represented by the combination received. These steps must now be taken up.

34. To control the sending keys by hand is possible, but a much more satisfactory method has been developed. This method makes use of two pieces of apparatus called a transmitter and a perforator.

35. Let us suppose that we make the sending keys in such a compact form that we can replace the key buttons by small pins and arrange them so that one end of these pins protrudes a short distance through holes in a small metal plate as shown in Figure 15.

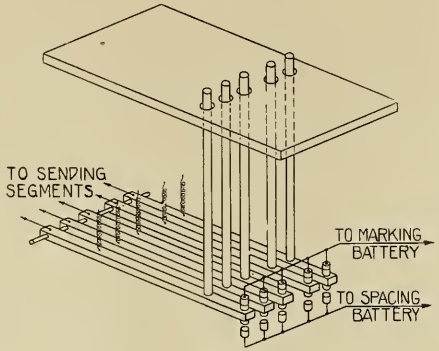


Fig. 15

Let us assume also that when we placed double battery on the keys we made the back contacts the "marking" contacts by connecting to them the polarity which, when con-

nected to the line by means of the keys, will send an impulse that will operate the selecting magnets at the other end of the line. Similarly, the lower contacts were made "spacing" contacts so that an impulse sent from them to the line will not operate the selecting magnets at the distant terminal.

**36.** If now we place over the protruding pins on the metal plate a ribbon or tape of some material such as paper, and hold it down tight, all the keys will be held against their spacing contacts, and no operating signals will be sent to the line by the brushes as they pass over the segments connected to the keys. If, however, we punch a hole in the tape directly over one of the pins so that it can pass through the tape, the key to which this pin is connected will be allowed to make contact with its upper, or marking, contact and when the brushes pass over the segment to which this key is connected an operating impulse will be sent to the line. By feeding a tape provided with properly punched holes over the five pins, step by step, signals corresponding to the Multiplex alphabet may be sent out at will.

**37.** Figure 16 represents a tape so punched. For the letter A, two holes are punched in the tape in such a position that one hole comes directly over pin number one, and another one comes directly over pin number two. This will permit these two corresponding keys to connect with their marking contacts, thus sending operating impulses to selecting magnets one and two at the distant end of the line, while keys 3, 4 and 5 send non-operating impulses to magnets 3, 4 and 5. As shown in Figure 11 this combination represents the letter A. In the same manner, when holes are punched as shown for the letter M, selecting magnets 3, 4 and 5 are operated at the distant end.

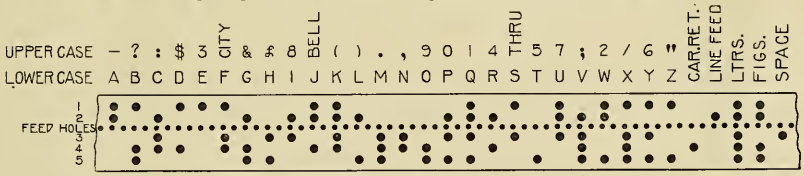
UPPER CASE — ? : $ 3 CITY & £ 8 BELL ( ) . , 9 0 1 4 THRU 5 7 ; 2 / 6 " CARR. RET. LINE FEED LTRS. FIGS. SPACE
LOWER CASE A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
FEED HOLES 1 2 3 4 5

Fig. 16

**38.** Some means must of course be provided for feeding the tape along automatically. A magnet is therefore placed in the transmitter with its armature so connected, by means of levers, etc., that three successive operations take place each time the magnet is energized. First the pins are withdrawn from the paper tape, then a small star, or feed wheel, is caused to rotate, and finally the pins are again released. The feed wheel engages the tape by means of the continuous row of small holes (Fig. 16) and each operation of the magnet causes the wheel to rotate just sufficiently to move the tape forward the distance between two successive holes.

**39.** To furnish an electrical impulse that will operate the magnet once each revolution of the distributor brushes, a third pair of rings called "Local Rings" must be added to the distributor. Now modifying Figure 14 to include the new features we have added we may represent one terminal set, showing only one channel as before, by Figure 17. The brushes for the local ring are placed at right angles to the receiving brushes for convenience in drawing and construction.

**40.** It should be noted that the local ring operating segment for the transmitter feed magnet is placed in such a position that this magnet operates after the sending brush has passed over sending segment five, and before it again reaches segment one. This is important because it allows all the moving parts of the transmitter to come to rest before the prepared signal is actually sent to the line.

**41.** The perforator is a mechanical device made up with a system of transverse levers, bars, etc., so arranged that by depressing keys on the keyboard the proper punches are selected and holes punched in the paper tape according to the alphabet shown in Figure 16. The keyboard is similar to a standard typewriter keyboard. The perforator is

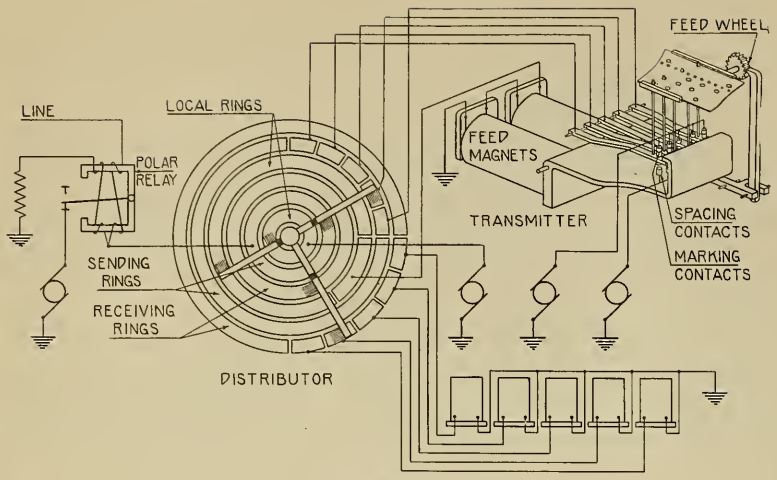


Fig. 17

not electrically connected with the other apparatus to the telegraph line, and for that reason will not be included in this general theory. For the present the reader may take it for granted that it is convenient to prepare a tape for the operation of the transmitter as already described. A full description of the perforator will be given in Section 4.

42. We come now to a description of the receiving apparatus. So far we have only shown that the five selecting magnets may be operated as determined by the characters punched in the paper tape, but we have said nothing about the way in which the operation of these magnets can be made to select and print the proper letter or character.

43. A number of different printers have been made for performing the work of translation. Some of these printers are essentially electrical in their operation, others essentially mechanical. In each of these two groups there are several types. In this section we shall describe only a selecting mechanism, and show how this can be made to operate the keys of an ordinary typewriter, and take up, in later sections, some of the different types of printers that are actually in use.

44. Figure 18 shows a set of five selecting bars, each notched along one edge. If they are placed side by side, the notches all on the same side and the ends even, it will be seen that these notches form a single path at only one point; that is, the slot formed is continuous across all five bars at only one point. If one of the bars is displaced a distance a-b to the left, the slot is continuous at another point, if two bars are displaced, the continuous slot is again shifted, and so on, depending on the particular bars displaced. In this manner thirty-two different continuous slots may be formed.

45. For purposes of illustration let us now assume that these five bars are placed under the key levers of an ordinary typewriter, as shown in Figure 19. The selecting bars are normally held in position by catches, or pawls, mounted on the armatures of the selecting magnets. When any one of these magnets is energized the catch is withdrawn and the selecting bar moves to the left under the action of its spring. Except when the bars are all in their normal positions there is a continuous slot directly in front of some one of 31 selecting levers, only four of which are shown in Figure 19. Since the combination set up when all the bars are in their normal positions is not used for selecting a character or function, the thirty second lever which should correspond to this position is omitted. Each selecting lever is mechanically connected with a hook attached to

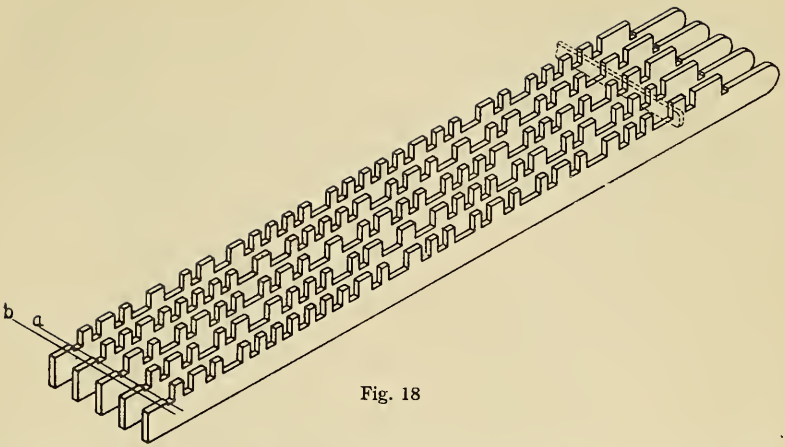


Fig. 18

one of the keys of an ordinary typewriter, as shown for the letter D, or has mounted on it a contact, as shown for the "line feed magnet"; that is, a magnet mounted so that when it operates it pulls the lever which rotates the platen of the typewriter.

46. If we now send a combination of impulses over the wire in such a manner as to operate one or more of the selecting magnets, as already described, the selecting bars are "set" in such a way as to place the continuous slot before the proper selecting lever. After this is done an impulse is sent from a segment (which we must now provide) on the local ring, to the "operating magnet." This magnet is also called the "sixth pulse magnet." The operation of this magnet permits four distinct operations to take place:

(a) As it pulls down the connecting link, a slot in this link allows the locating bar to slide back out of the way of the selecting levers. The one that is opposite the continuous slot therefore moves into the slot so far that the hook is pushed under the printing bail.

(b) The printing bail to which the connecting link is attached engages with the hook of the selected letter and pulls down the letter key lever, thus printing the letter.

(c) Immediately after the hook on the selected letter has been engaged by the printing bail, and while the actual printing of the letter is taking place, the connecting link forces the locating bar forward, thus moving the selected selecting lever out of its slot again.

(d) Just as the operating magnet completes its stroke it closes the reset contacts, thus sending an impulse from a local battery through the reset magnet to ground. The operation of the reset magnet pulls all the selecting bars back to their normal position. When the operating magnet is de-energized the connecting link, printing bail, the selected letter, etc., are released and returned to their normal positions.

47. If the selection had been one that called for rotating the platen in place of the printing of a letter, the contact connected to the corresponding selecting lever would have closed, and since there is no hook on the line feed lever, no letter would have been printed, but an impulse would have been sent from local battery through the line feed function contact to the line feed magnet to ground, thus operating this magnet and causing the platen to rotate; after which the operation of the sixth pulse magnet would reset the selecting bars as before.

48. This typewriter and selecting mechanism, when added to the set shown in Figure 17, completes the apparatus needed at each terminal for operating a duplexed line with this simple Multiplex system. (One channel only.) This system is capable of simultaneously transmitting and recording in Roman characters on message blanks one message per channel in each direction.

49. In actual construction many refinements and additions have been found necessary. These are all taken up under the description of each individual unit. The foregoing covers only the principles upon which the system operates and should be clearly understood before attempting to learn the individual features of the units which make up the system.

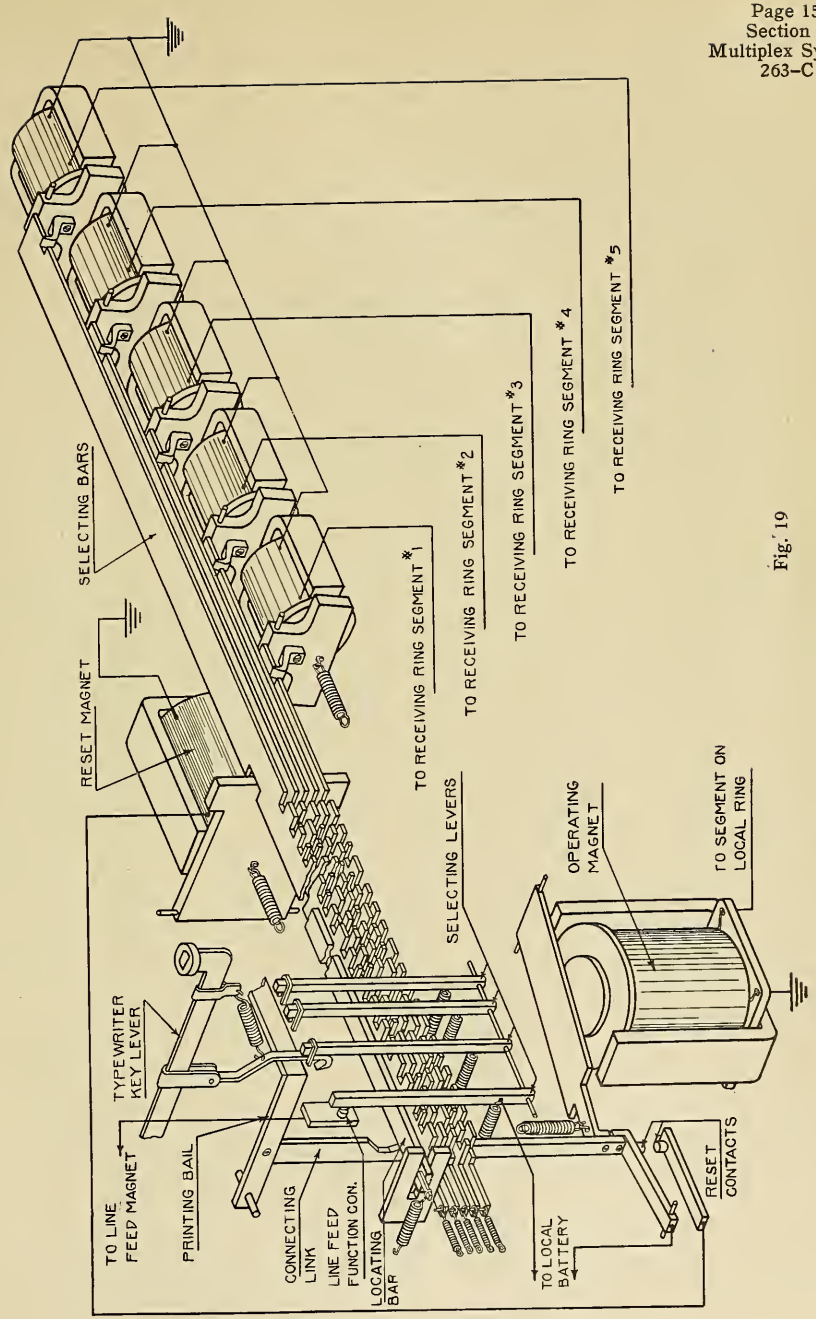
SELECTING BARS
RESET MAGNET
TO RECEIVING RING SEGMENT *1
TO RECEIVING RING SEGMENT *2
TO RECEIVING RING SEGMENT *3
TO RECEIVING RING SEGMENT *4
TO RECEIVING RING SEGMENT *5
SELECTING LEVERS
OPERATING MAGNET
TO SEGMENT ON LOCAL RING
TYPEWRITER KEY LEVER
TO LINE FEED MAGNET
PRINTING BAIL
CONNECTING LINK
LINE FEED FUNCTION CON.
LOCATING BAR
TO LOCAL BATTERY
RESET CONTACTS

Fig. 19

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 2

## MULTIPLEX DISTRIBUTOR AND ITS ASSOCIATED APPARATUS

These Specifications are the property of the Western Union Telegraph Company and shall not be published.

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SPECIFICATIONS INCLUDED: None.

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| 1 | Photograph | Driving Fork for Distributor Motor. |
| 1-A | Photograph | Distributor. |
| 2 | 22316- -2 | Distributor Motor. |
| 3-A-B-C | 22317- -3 | Distributor Motor Theory. |
| 3-D-E | 22336- -2 | Wiring Diagram of Distributor and Driving Fork. |
| 4 | 22318- -2 | Corrector. |
| 5 | 22319- -1 | Distributor Face Plate and Brushes Mounted. |
| 6 | 22320- -1 | Connector Plug. |
| 7 | 4554- -1 | Distributor Connector Panel Circuits. |
| 8 | 22321- -1 | Arrival Curves. |
| 9 | 22322- -1 | Combination Relay Circuit Theory. |
| 10 | 22323- -1 | Combination Relay Circuit Theory. |
| 11 | 22324- -1 | Combination Relay Circuit Theory. |
| 12 | 22325- -1 | Combination Wheatstone Relay Applied to Multiplex as Main Line Relay. |
| 13 | 22326- -1 | Synchronizing Unit Wiring Diagram. |
| 14 | 22327- -1 | Synchronizing Theory. |
| 15 | 22328- -1 | Correction and Lag Compensation Theory. |
| 16 | 22328- -1 | Correction and Lag Compensation Theory. |
| 17, 17-A-B-C | 22329- -1 | Lag Compensation. |
| 18 | 22330- -1 | Cam Switch. |
| 19 | 13833- -1 | Chart of Quadruple Face Plate (for Terminal Set only). |
| 20 | 13834- -1 | Triple Face Plate (for Terminal Set only). |
| 21 | 13835- -1 | Double and Single Face Plate (for Terminal Set only) |
| 22 | 22331- -1 | Fork Contact Adjustment. |
| 23 | 22332- -1 | Pole Piece Adjustment. |
| 24 | 22333- -1 | Motor Speed Adjustment. |
| 25 | 4562- -1 | Brush Setting Jig. |
| 26 | 22334- -1 | Brush Hub Adjustment. |
| 27 | 22335- -1 | Corrector Adjustment. |

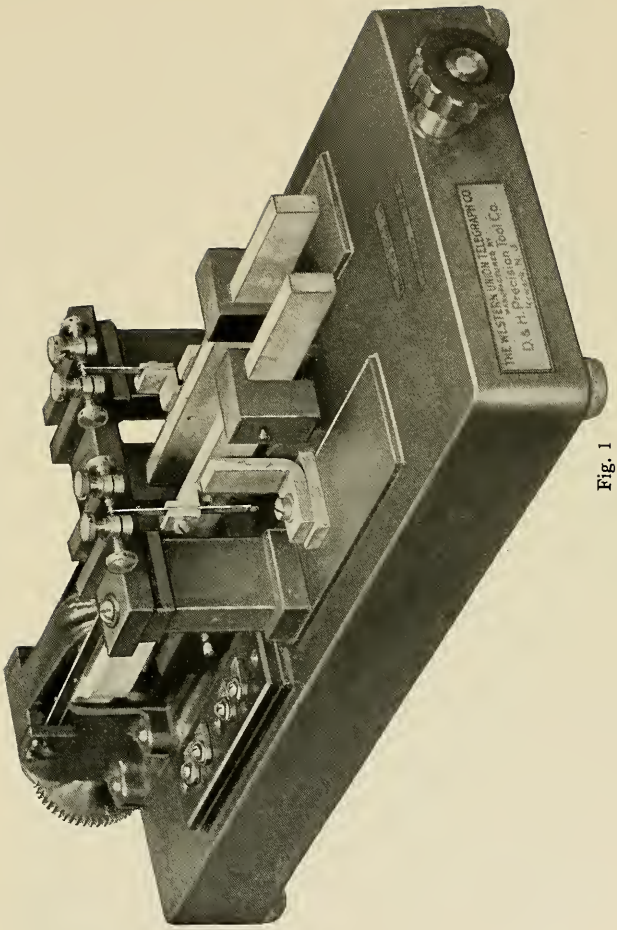



Fig. 1

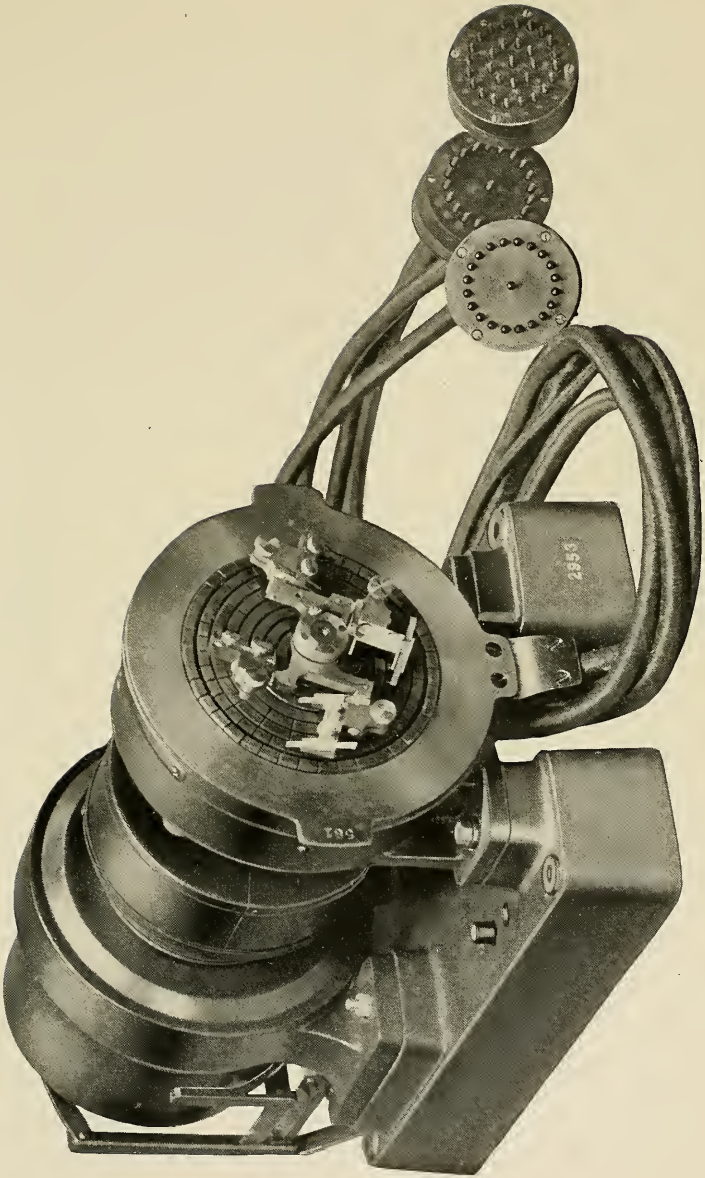


Fig. 1-A

## MULTIPLEX DISTRIBUTOR AND ITS ASSOCIATED APPARATUS

1. In section 1 we purposely avoided reference to the method for driving the brushes of the distributors, other than that they were rotated synchronously. We now must describe the method used to obtain this synchronous rotation.

2. The first requisite in obtaining this condition is to choose as our source of mechanical power a form of motor which is the least subject to extraneous changes that may affect the speed of the motor. The La Cour wheel, or, as it is sometimes called, the phonic wheel, or impulse motor maintains an almost constant rate of speed under varying conditions and was therefore selected for driving the distributor of the Multiplex System.

3. It consists essentially of three parts:

(a) A source of electrical impulses the frequency of which can be altered.

(b) A toothed, revolving armature of magnetic material.

(c) An electromagnetic field.

4. In the Multiplex System the source of the electrical impulses is an electrically operated tuning fork. It is characteristic of well made tuning forks that they vibrate, after having been set in motion, at practically an unvarying speed. The speed of vibration depends upon the length, cross-section, mass, and distribution of the weight of the tines of the fork. Thus by varying any one of these factors the speed of the fork may be altered. The forks used in the Multiplex System are equipped with weights which may be placed in different positions on the tines, thus changing the mass of the tines, and the distribution of its weight.

5. In order that the fork may be kept in continuous vibration, after having been set in motion by hand, the fork is equipped with an electromagnetic driving device which may be clearly understood by referring to Figures 1 and 3.

6. The driving magnet is located in the base of the fork with its polepieces extending upward on the outside of the fork tines. One terminal of this magnet is connected to the contact screw located just above the right hand tine of the fork. A contact spring is mounted on the right hand tine of the fork directly below the contact screw. It is connected through the base of the fork to the second terminal of the source of electric current. This contact spring and its associated contact are called fork driving contacts.

7. If the tines of the fork be pinched together, the contact spring makes contact with the contact screw, closing the electric circuit through the magnet, thus magnetizing the polepieces. They in turn attract the tines of the fork, tending to pull them outward. If we release the tines they will swing out, away from each other, thus breaking the contact between the spring and screw, and continuing under the natural tendency of the tines to vibrate, they will complete their oscillation outward and then swing inward. As they do so they again make contact between spring and screw and are given a second short pull outward. This making and breaking recurs periodically for every vibration of the fork so that the fork is kept in continuous vibration.

8. The contacting device shown in connection with the left hand tine of the fork is used in driving the La Cour wheel, and will be described in connection with the operation of the motor in a later paragraph.

9. Sliding weights are attached by flexible links to a sliding device controlled by a hand wheel at the front of the fork base. These weights are used for changing the speed of the fork when it is desirable to make only a small change in the frequency. The fork vibrates approximately three cycles per second faster when these weights are against their rear stop than it does when they are placed as far forward as possible. They can be moved while the fork is in motion.

10. When it is desired to make a greater change in the frequency than permitted by the use of the sliding weights, adjustment of the removable weights must be resorted to. These cannot be moved without stopping the fork. Three sets of these weights are furnished with the multiplex fork, by means of which any fork frequency, from about 25 to 59 cycles per second, may be obtained. For convenience the weights are designated by the letters A, B, and C; A being the largest set and C the smallest.

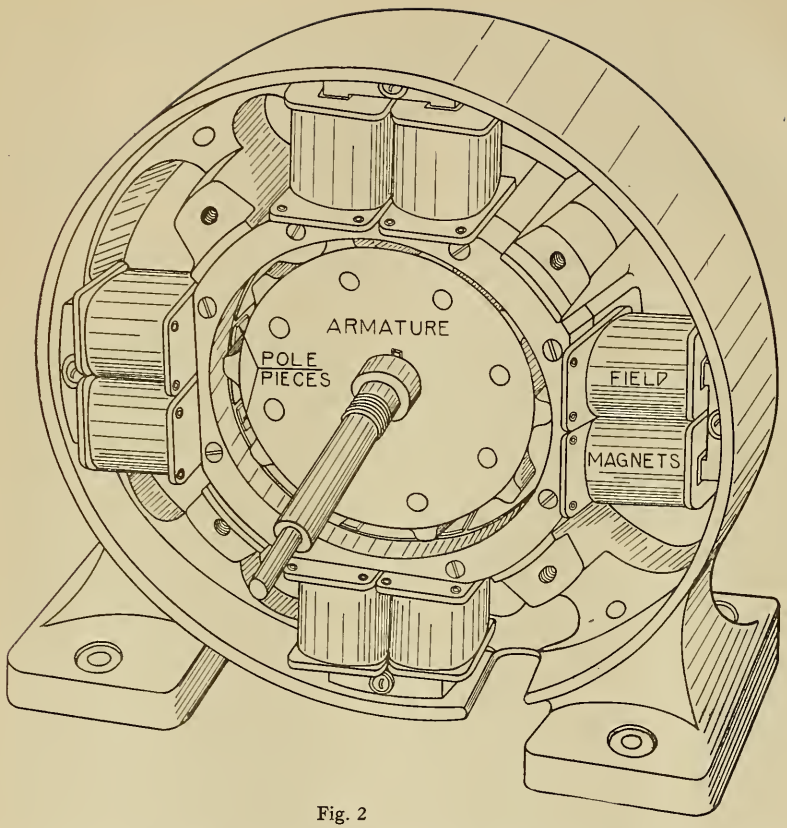



Fig. 2

11. Figure 2 shows the construction of the La Cour wheel. The armature is made up of laminations of silicon steel firmly riveted together between two brass end plates. The electromagnetic field is produced by four sets, or pairs, of magnets, the cores and yokes of which are made of laminated silicon steel.

12. Figure 3 A, B, C, D and E shows a diagrammatical sketch of the motor and its driving fork; also the actual wiring diagram of these units. Reference to this figure, also Figure 1, shows that the left hand tine of the fork also carries a contact spring so mounted that when the fork is in motion it makes and breaks contact with two contact screws placed directly above it. This spring and associated contacts are called motor driving contacts. In the position shown in Figure 3A, current therefore flows from the source of supply through the fork base and motor driving contact spring to its right hand contact screw, thence through the right and left hand driving magnets in the motor, the differential mil-ammeter, the rheostat, and finally to the second terminal of the source of current. The energization of the magnets causes the formation of a magnetic field through the polepieces and yoke of the magnets and the teeth of the armature as shown by the dotted lines, and, since it is a property of such fields to shorten their paths if possible, the armature is made to rotate until it takes the position shown in Figure 3B.

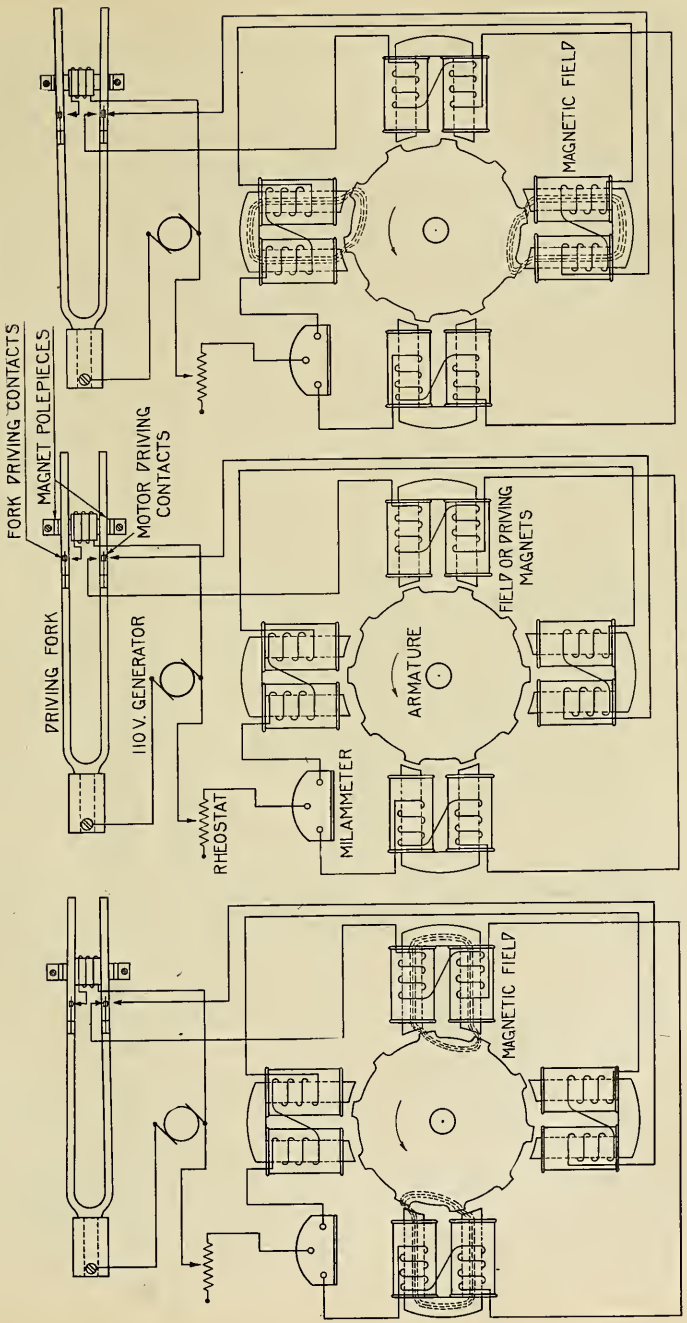
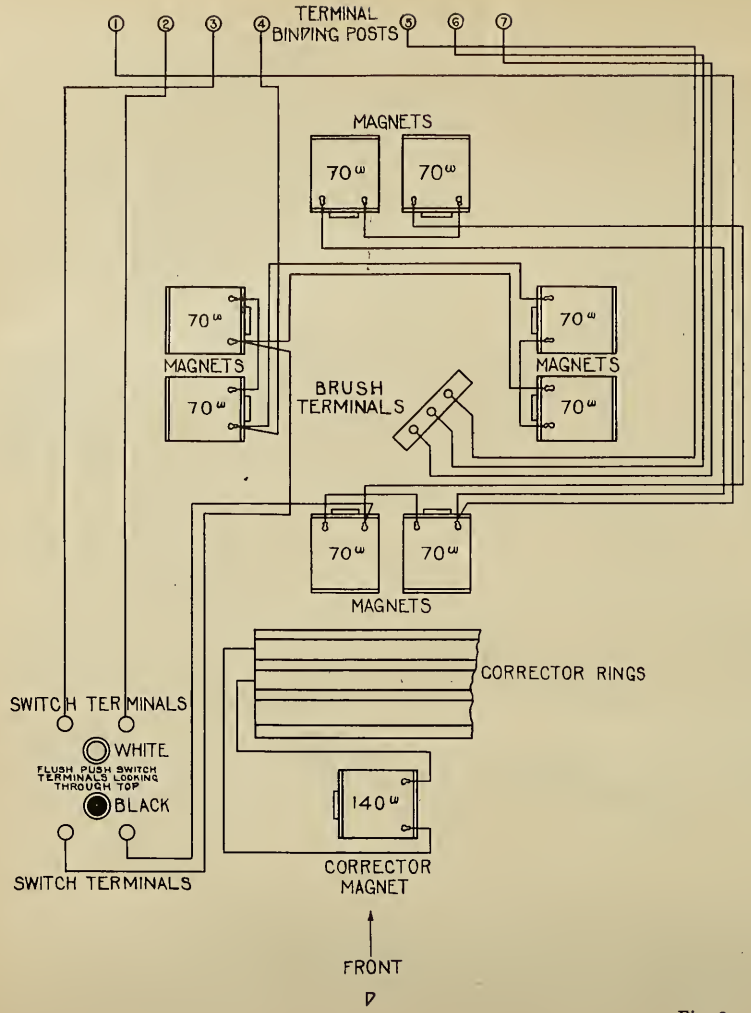
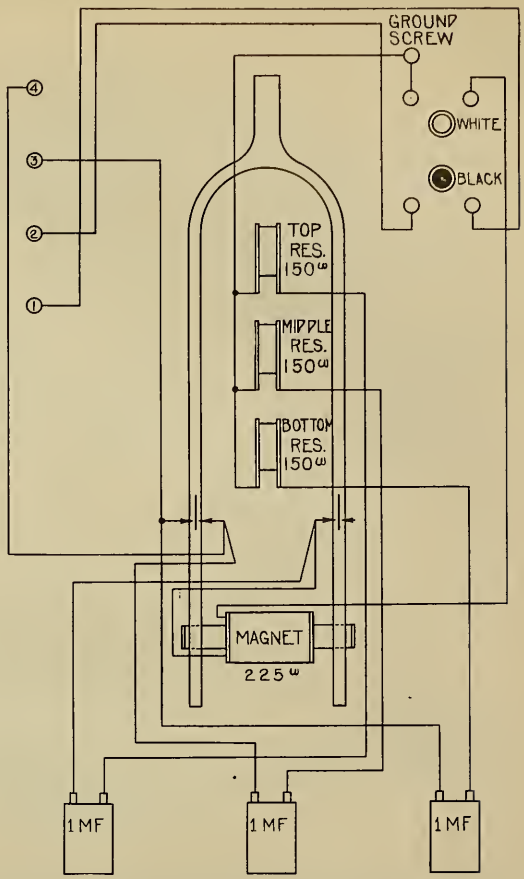

FORK DRIVING CONTACTS
MAGNET POLEPIECES
DRIVING FORK
MOTOR DRIVING CONTACTS
110 V. GENERATOR
RHEOSTAT
MILAMMETER
ARMATURE
FIELD OR DRIVING MAGNETS
MAGNETIC FIELD
A
B
C

Fig. 3




NOTE: CONNECTIONS ON APPARATUS BOTH ON AND BELOW THE BASE SHOWN AS IF LOOKING DOWN ON AND THROUGH THE BASE.

E

Fig. 3.

By the time it reaches this position, however, the tines of the fork have moved out to a position where the motor driving contact spring no longer makes contact with the right hand screw. The armature continues to revolve for a short time due to its momentum and when it reaches the position shown in Figure 3C, the motor driving contact spring has made contact with the left hand screw, thus closing a circuit from the local generator through the base of the fork, the other pair of magnets, the differential mil-ammeter and resistance to the generator. This causes a field to be built up through the polepieces and yokes of these magnets and teeth of the armature, as shown in the dotted lines (Figure 3C). This again gives the armature an impulse in the same direction as before. By being thus alternately energized and de-energized from the tuning fork, the magnets impart to the armature a series of impulses that will keep it in continual rotation, provided it is once started and brought to a speed corresponding (with respect to the number of its teeth) to the speed of energization and de-energization of the magnets. Since this is dependent upon the speed of the tuning fork, we can readily see that the speed of the motor may be altered by changing the frequency of the fork, as already described.

**13.** Since the circuits to which current is supplied by the contacts on the fork are highly inductive, it is necessary to bridge these contacts with some device for taking up the spark which would otherwise burn the contact surfaces. Condensers connected in series with a small resistance are commonly employed for this purpose. When so used they are termed "spark condensers." The spark condensers for the fork are shown on Figure 3E. In our study of the multiplex we will find these condensers used in a great many places.

**14.** The mil-ammeter mentioned in tracing the circuits through the magnets, as well as the resistance, is used for properly controlling the operating current for the motor and will be referred to further under the directions for adjusting and operating the apparatus. The resistance is NOT used to change the speed of the motor.

**15.** Unless some means is provided to steady it, the rotation of the La Cour wheel will be "jerky," a feature which is detrimental in the operation of synchronous apparatus. The motors used for the multiplex distributors are therefore equipped with a heavy, mercury filled flywheel. This flywheel takes up the excess energy imparted to the motor during the short impulses and redistributes this energy over the interval during which no motion is imparted to the armature by the magnets. The wheel is filled with mercury, first, because of its great density, and second, because of the fact that it is fluid. When the motor speed falls off, the mercury inside the flywheel tends to continue to rotate, thus causing friction between the mercury and the inside of the wheel. This frictional force tends to prevent the wheel from changing its speed. In the same manner, if the speed of the wheel tends to increase, the frictional force brought into action by the mercury opposes the change in velocity.

**16.** As already stated, the La Cour wheel is not self-starting. A small direct current motor is placed near it on a pedestal which is so pivoted that by turning the motor slightly a rotating friction wheel on the starting motor is brought into contact with the flywheel of the La Cour wheel. It is held there until this motor has been brought to the proper speed, when the impulses from the fork will "pick up" the armature and keep it in rotation.

**17.** The La Cour wheel which we have described maintains, as already stated, a very nearly constant speed, but even two of these motors cannot be depended upon to maintain synchronism permanently, unless some means is provided for frequently checking the relationship between them.

**18.** To provide this check a mechanical "corrector" is used as a connection between the motor shaft and the shaft that carries the distributor brushes. Its function is to rotate one shaft with respect to the other when for any reason the motors at each end of the line are not maintaining their synchronous relation.

**19.** While it is quite practicable to provide means for correction by either advancing or retarding the brush shaft with respect to the motor shaft, or by both, the apparatus is much simplified by allowing one motor to maintain a speed slightly higher than the

other, and to correct at this end only by frequent slight retardations of the brush shaft. To provide for flexibility, however, all distributors are equipped with correctors, together with suitable switches for cutting out those not actually in use.

20. The corrector, a drawing of which is shown in Figure 4, is mounted on the motor shaft and revolves with it. The magnet is connected to the collector rings which, by means of brushes, may be connected to any external circuit. The armature of the magnet operates a pawl which engages a ratchet wheel. This wheel is rotated one tooth each time the magnet is energized. A jockey keeps the ratchet wheel in position and prevents it revolving unless it is properly operated by its feed pawl. The ratchet wheel is rigidly attached to its shaft which also carries a small pinion. This pinion meshes with a gear placed on the end of the distributor brush shaft.

21. As the whole corrector revolves with the La Cour wheel the corrector pinion and brush shaft gear act as a direct coupling, causing the distributor brush shaft to revolve with the motor shaft. If, however, the corrector be operated, the magnet attracts its armature and in so doing rotates the ratchet wheel and the small pinion. This in turn rotates the brush shaft gear through a small angle (one and one-half degrees) in the opposite direction to the direction of motor rotation. In other words, the brush shaft is

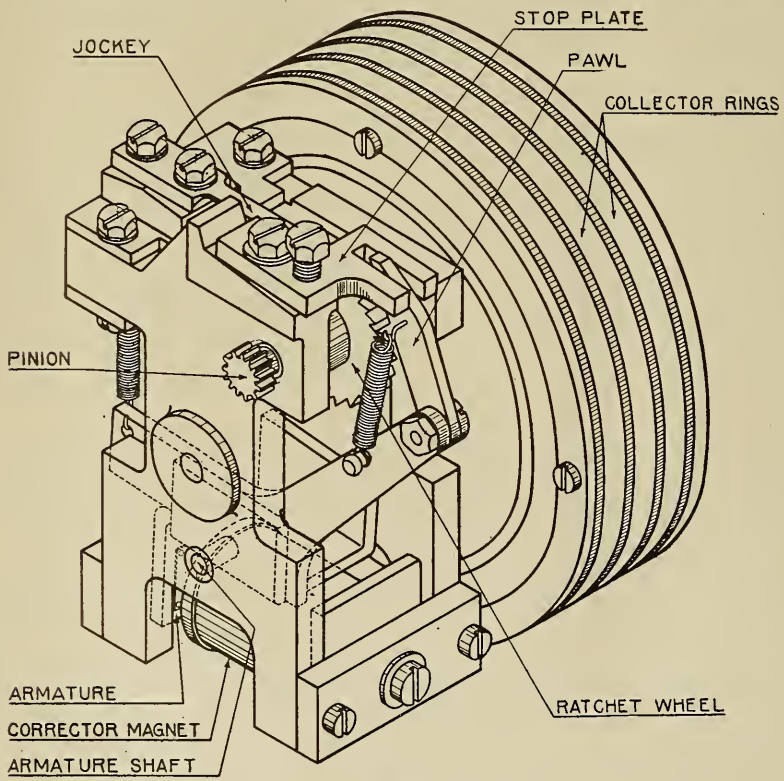



Fig. 4

retarded one and one-half degrees with respect to the motor shaft each time the corrector is operated. The means for operating the corrector will be described in a later paragraph.

**22.** The rings which serve to connect each unit of the Multiplex System to the telegraph line at the proper time, etc., spoken of in Section 1, are made up into a so-called distributor face plate. The face plate and its mounting, as well as the brush shaft and holder, are shown in Figure 5. Here we have four pairs of rings; not three pairs as described in Section 1. This is due to the fact that an extra pair of rings is required for the correcting mechanism, and since this was not needed in building up the simple system described in Section 1 it was omitted. It will be taken up here in connection with the synchronizing apparatus.

**23.** The outer segmented ring is the receiving ring. For a four-channel set it is divided into 40 equal segments. Only alternate segments are used for the operation of the printer selecting magnets as described in Section 1. Sixteen of the other twenty segments are used for operating four so-called "tie up" or "pilot" lamps, one for each printer. These lamps indicate to the operators whether or not the printers should be printing and thereby

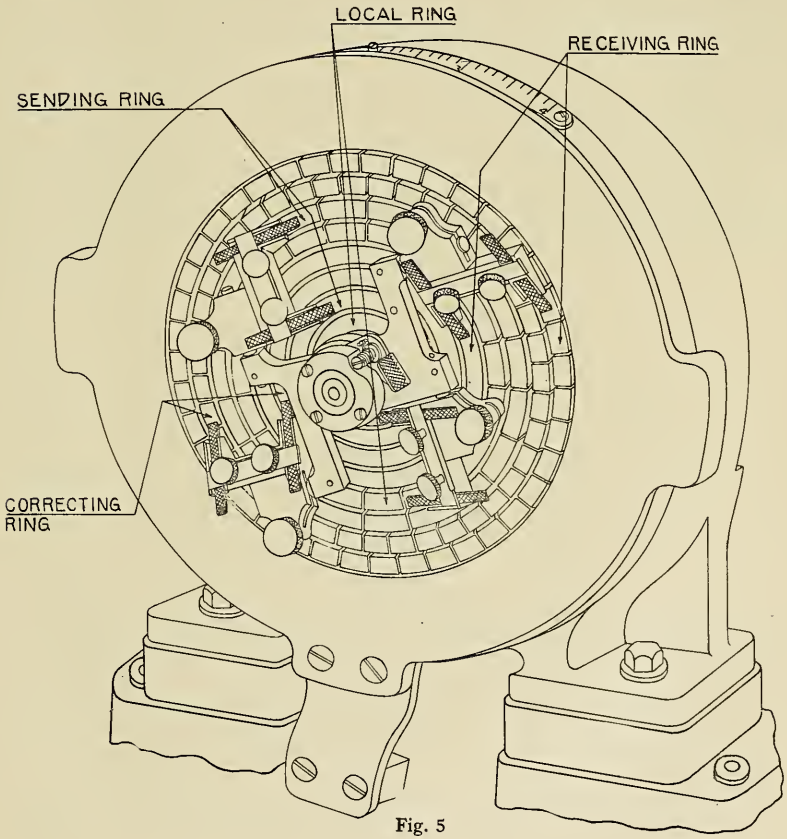



Fig. 5

serve to prevent the possibility of the distant station continuing to send when for some reason the receiving printer is not operating. These lamps will be further described in connection with the printers. This ring is not rigidly fastened to the other rings on the face plate but may be rotated through an angle of about 30 degrees with respect to the other rings, thus providing an adjustment which is used in obtaining the proper relationship between the brushes.

24. The second ring is the correcting ring. For a four-channel set it consists of 40 segments. For convenience they are numbered 1A, 1B, 2A, 2B, etc. Segments 1A to 19A inclusive are connected together; segments 1B to 19B are connected together; segments 20A and 20B have separate leads. The A segments are used for operating the corrector, the B segments, usually called the "dead" correcting segments, are idle.

25. The third ring is the sending ring. Segments 1 to 5 inclusive are connected to the transmitter on the first channel, 6 to 10 to the second channel, and so on.

26. The fourth ring is the local ring. Segments 6-7-8 operate the first channel transmitter; segment 9 the printer of the first channel. Segments 11-12-13 operate the transmitter on the second channel; segment 14 the printer on this channel. Segments 16-17-18 operate the transmitter on the third channel and segment 19 the printer on this channel. Segments 1-2-3 operate the transmitter on the fourth channel, segment 4 the printer on this channel.

27. Ring five is the solid receiving ring, six the solid corrector ring, seven the solid sending ring and eight the solid local ring.

28. The various solid rings and segments of the distributor face plate are connected to pins in three multiple unit connector plugs, one of which is shown in Figure 6. These are so arranged that the distributor face plate may be readily and conveniently disconnected from the distributor terminal box. They are also used in adjusting for lag in transmission. This will be referred to later.

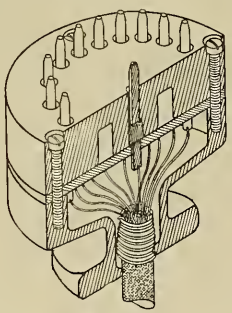


Fig. 6

29. One plug is connected to the rings and segments used in selecting and correcting and is called the receiving and correcting plug. A second plug is connected to the segments and ring used in sending and is called the sending plug. The remaining plug is connected to the ring and segments used for local purposes and is called the local plug.

30. The receiving plug consists of an arrangement of 30 pins wired as follows: Twenty alternate segments of receiving ring number 1 are connected to the outer ring of 20 small pins located within the multiple unit plug. The center pin R is wired to the solid ring number 5.

31. The pin K19 is wired to the 19 "B" segments of the correcting ring. The pin K1 is connected to segment 20 B. S1 is connected to segment 20A and S19 is connected to the 19 A segments of the second ring. Pin A is wired to the four tie-up lamp segments

on the receiving ring number 1 between the segments 1 to 5; that is, pin A is wired to the segments 1A, 2A, 3A and 4A. Pins B, C and D are similarly wired to segments 6A, 7A, etc. No pins or connections are provided for segments 5A, 10A, 15A or 20A. Pin RS is wired to the solid correcting ring number 6. The receiving and correcting plug is not arranged to be shifted for any purpose whatever, but simply is a convenience, as mentioned above, for disconnecting the distributor face plate from the terminal box, when found necessary to do so. Figure 7 shows the terminal panels containing the small sockets into which the pins of the multiple plugs enter. The small sockets or spring jacks are wired to the corresponding terminals on the panels in the terminal box.

**32.** The sending plug consists of an arrangement of 20 small pins arranged in a circle and one pin at the center. The 20 segments of ring number 3 are wired to the 20 corresponding pins of the plug; while ring number 7 is wired to the center pin. The small sockets or spring jacks numbered 1 to 19 inclusive are wired to the terminals 1 to 19 on the distributor panel. Socket number 20 is wired to terminal number 20A, from whence the circuit normally goes to terminal 20B, and finally to terminal number 20.

**33.** Under certain conditions this plug is transferred and inserted in the balancing or Alternating Current block. The alternate spring jacks or small sockets of the Alternating Current block are connected to one pole of the line battery, and the remaining sockets to the opposite pole of the line battery as already mentioned. The pin in the center of the sending multiple unit plug is connected to the solid sending ring number 7. The center socket of the balancing block into which this pin fits is connected to the corresponding or center socket of the sending ring terminal panel. Thus when the sending plug is inserted in the Alternating Current block, alternate impulses of positive and negative line battery are sent to the line as the sending brushes of the distributor pass over the segments.

**34.** The local plug connects the local rings number 4 and number 8 to the corresponding sockets or spring jacks in the terminal box. The sockets are wired to the corresponding terminals on the local panel, although all of the terminals are not used for electrical connections.

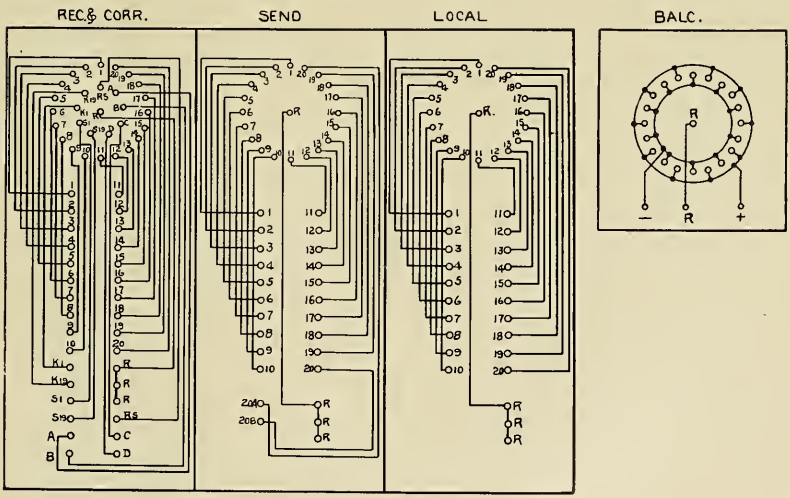



Fig. 7

35. Before completing the description of the distributor by showing the method of effecting the correction we will digress at this point to make an examination of the signals which must be received by the distributor, and which must in turn operate the printers as well as the correcting apparatus.

36. As the brushes at the sending station pass over the sending segments they send to the telegraph line positive and negative impulses of a definite positive and negative current value, but in the telegraph circuit itself there are several factors which tend to distort or change the wave form of transmitted impulses, so that the form of the wave at the receiving station is usually quite different from what it was when it left the sending distributor.

37. These factors are resistance, self-induction, mutual induction, induction from power or other foreign circuits, capacity, leakage to earth, "cross fire" or leakage from wire to wire, and earth currents. The longer the line the greater the effect of these factors upon the signals.

38. Resistance cuts down the current value and retards the propagation of the signal. Self-induction reduces the magnitude of the current wave, rounds off the corners of the wave form, retards its propagation and opposes a reversal of current. Mutual induction or induction from other lines alters the contour of the wave form and gives it a zigzag appearance, and in some cases may be so great as to destroy the wave completely. Capacity further retards the propagation of a signal and changes the wave form. Leakage to earth reduces the value of the current received at the distant station. "Cross fire" has almost the same effect as mutual induction. Earth currents distort also the wave form, sometimes making a plus wave of greater magnitude than a minus wave, and vice versa, and thus they produce what is known as a biased line.

39. Some of the forms the current waves are compelled to assume, on account of the above mentioned factors, are shown in Figures 8 A, B, C, D, E. In these figures the horizontal distances along OX represent lapse of time while vertical distances along OY represent current values. Figure A represents the wave form of the transmitted current of one unit duration passing through a very short length of wire. Figure B represents the general form this half wave would have at the receiving station if it were acted upon by self-induction, capacity, and resistance only. It will be noticed that its magnitude is considerably reduced and that its corners are rounded to a greater extent. Figures C, D and E are some of the forms these current waves assume when acted on by the combined disturbing factors. It will be noticed from Figure C that the contour of the line is zigzag, which is caused by mutual induction and cross fire, that its amplitude is less and that the end of the impulse has tailed off into the time unit of the succeeding impulse. In Figure D a deep indentation will be noticed in the curve. This may be caused by a strong surge of mutual induction or cross fire.

40. To minimize these disturbing effects of the line on the operation of the Multiplex two means are employed. First, the use of a special type of polar relay, the operation of which depends not only on the current received from the line but also upon certain local conditions. Second, by modifying the receiving segments so as not to utilize that portion of the incoming wave which is unreliable.

41. The relay is known as a Combination Wheatstone Relay. It is a modification of the Wheatstone relay and is provided with two auxiliary windings for the purpose of increasing the speed and working efficiency of automatic circuits, as well as for increasing operating margins on other circuits. One of these windings is referred to as an "Opposing Coil" and the other as an "Accelerating Coil."

42. The function of the opposing coil is to quicken the action of the relay by utilizing some of the energy derived from the regular local current to start the armature in motion well in advance of the arrival of the incoming line current.

43. The particular function of the accelerating coil is to impart impetus and strength to the armature movement after it has once been started by the action of the opposing coil, and to assist the line current in carrying the armature over to its appropriate contact stop.

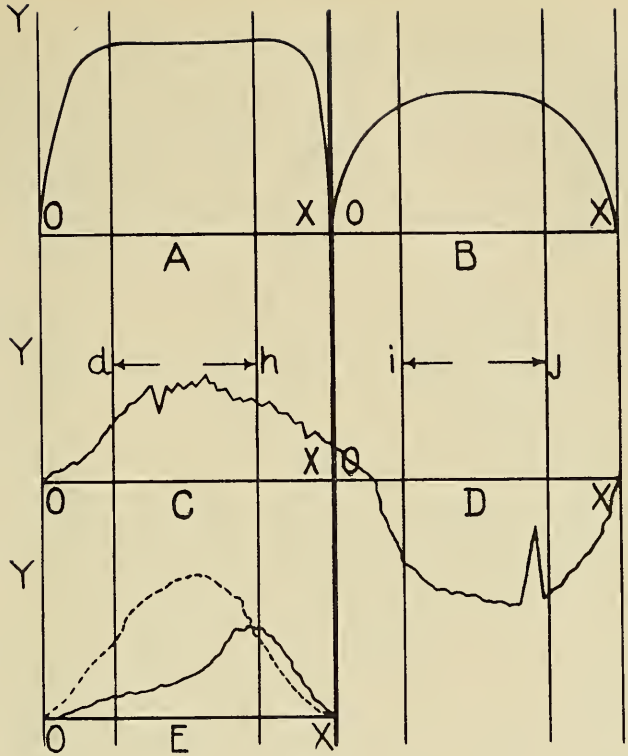



Fig. 8

**44.** Figures 9-10-11 illustrate by means of the current relations, how the Combination Wheatstone Relay speeds up the circuit in which it is used. In these diagrams, AL, represents the artificial line; AA, the Accelerating Coil; OO, the Opposing Coil; M, the marking contacts; S, the spacing contacts; R, resistance; C, condenser; and S′ and N′, the fixed magnetic polarity of the relay armatures. The other letters represent designations stamped on the base of standard Wheatstone relays. Arrows point in the direction current is flowing, or tends to flow. For convenience in explanation only those parts of the apparatus directly affected are shown in the diagrams. The home sending apparatus which should not influence the home relay, has been omitted and a grounded resistance shown in its place.

**45.** Figure 9 shows the steady current directions in the windings of the two relays when the distant transmitter is in the marking position. An inspection of this diagram will show that the direction of current in the opposing coil is such as to tend to neutralize that of the main line coil. As, however, the strength of the local current is considerably less than that of the main line current, the latter prevails, and holds the relay tongue against its marking stop as shown. Due to the drop across the resistance, R, the condenser C receives and holds a charge directed as shown. The action of this charge is explained in the paragraphs following.

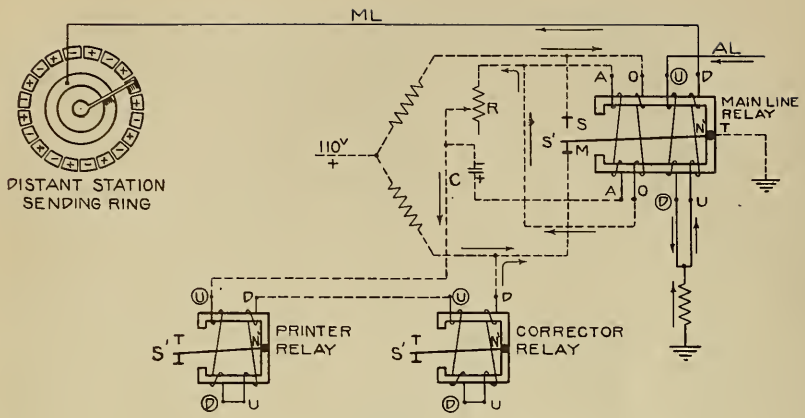



Fig. 9

46. When the distant transmitter reverses the direction of main line current, there is necessarily an interval during which the main line is entirely cut off from a source of current. During this period the main line current falls in value until the local current flowing through the opposing coil predominates enough to start the armature toward the spacing contact.

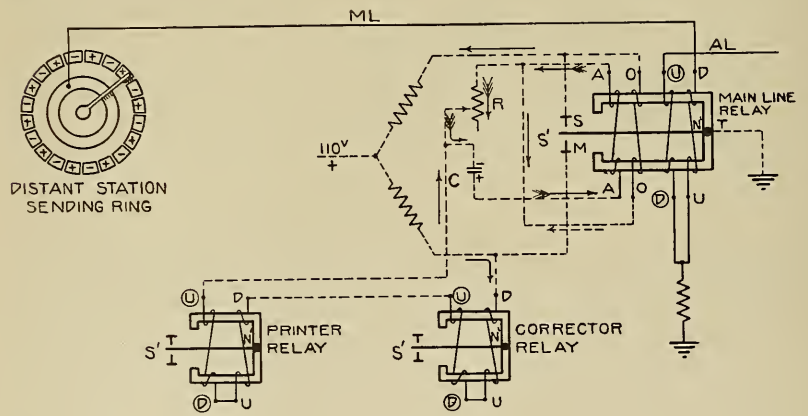



Fig. 10

47. At this instant the current conditions shown in Figure 10 are brought about. The condenser C discharges through the Accelerating Coil over the path shown by the feathered arrows, causing this winding to throw the armature of the relay with considerable force toward the "Spacing" contact. The discharge before returning to the condenser divides, part returning through the resistance R and part, by overcoming the self-inductance of the "Opposing Coil," returning through the windings of the Printer and Corrector Relays in such a direction as to start their armatures toward their "Spacing" contact. The direction in which the self-induced current tends to flow is indicated by

the dotted arrow. The plain arrow represents the direction of flow of the condenser discharge which overcomes this tendency and influences the Printer and Corrector Relays.

**48.** By the action of the auxiliary windings and the shunted condenser arrangement, the actions of the two relays are hastened until they operate nearly, if not quite, as quickly as the distant transmitter; that is, when the reversed current again flows in the main line, the printer and corrector relay tongues will already be in motion. Figure 10 shows the current conditions in the various windings when equilibrium has been reached with the distant transmitter on its spacing contact. A subsequent reversal will bring about all the momentary current conditions shown in Figure 10 except that all currents will be reversed in directions.

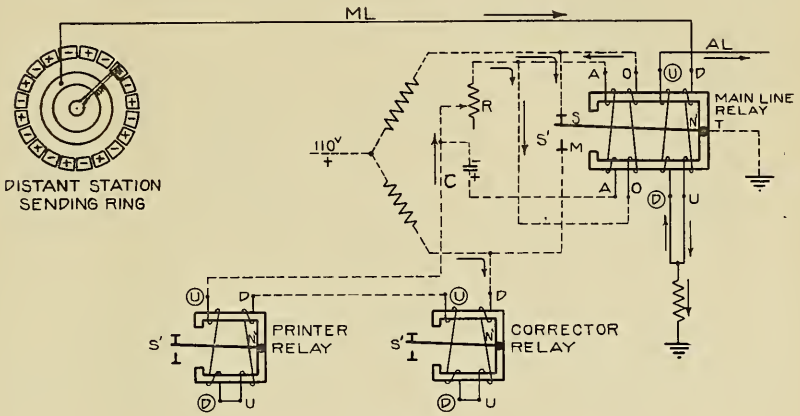



Fig. 11

**49.** It will be obvious that the work of the line current is being chiefly confined to holding the armature against one or the other of its contact stops for the length of time required to develop the signal, and that the actual movement of the relay tongue is largely controlled by local currents.

**50.** A skeleton diagram of the relays used is shown in Figure 12. The resistance R and capacity C are assembled for convenience in an instrument called a combination regulator.

**51.** As the local circuit scheme involves the use of but one polarity of current at the contact points of the relay, the latter may be very closely adjusted without danger of sparking or arcing, immunity from which also obviates the necessity for the frequent filing and cleaning of the points.

**52.** The amount of steady direct current in the local circuit is determined by resistance R, the precise value of which, however, is not so very critical, but should generally be such as to permit a current strength of about 15 mil-amperes, which in conjunction with the current discharge from the condenser is sufficient to efficiently operate the local relay. The direction of this current, it will be noted, is reversed through the windings of all the local apparatus whenever the relay armature changes its position in response to the current reversals in the main line.

**53.** To obviate bias in the local circuit, the adjustment of the line relay need only be such as to cause the needle of the local mil-ammeter to vibrate about its zero position when rapid uniform reversals are being sent out by the distant distributor.

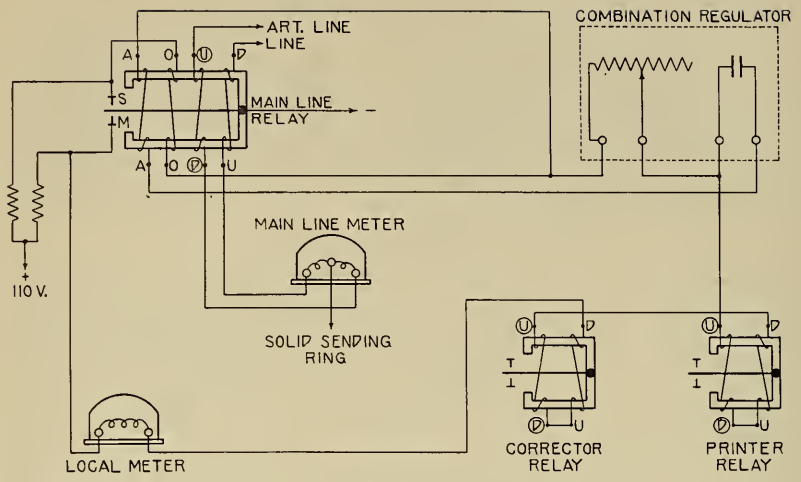



Fig. 12

54. The amount of capacity in the shunted condenser is fixed at 2 microfarads.

55. With the Combination Wheatstone Relay no departure from existing methods is necessary for securing the regular ohmic and static balance for duplex working.

56. The second method for minimizing the detrimental effects of line interference consists, as already stated, in modifying the receiving segments. We noted in describing the distributor face plate that the receiving ring had 40 segments, but the sending ring only 20; also that only alternate segments of the receiving ring were used for operating the selecting magnets in the printers. Now referring to Figure 8 again, the length of the line OX on Figures A, B, C, D, E represents the time required for the brushes to pass over one segment of the sending ring. That portion of the impulse represented by d and h, i and j is the middle half of the respective curves. The distances between d-h and i-j represent the time of travel of the brushes over the face of a receiving segment. Consequently only half of a full transmitted marking signal is utilized for the operation of the selecting relay. This half is taken from the middle portion of the wave, however, and is of maximum value. The two other portions of the curve, or the beginning and ending of the signals C and D, are used only for the operation of the "tie up" lamp, the proper operation of which is not nearly so important as the selection of the correct magnets in the printer. The form of the curves at these points is consequently not so important as in systems which use the full length of impulse. The overlapping of one wave into the other, as shown in C and D, will have no detrimental influence on the selecting relays of the printer. Another point that might be brought out here is that when the curve C has dropped to its zero point X or the instant of no current, the line receiving relay is responsive to any inductive influence on the line and may be operated thereby. The shortening of the receiving segments protects the selecting relays from false signals when the main line relay is most sensitive to inductive disturbances, and also allows the speed of the brushes of the two stations to vary between wider limits without the danger of signals overlapping each other, as would be the case if the receiving segments were of full length. By using only the middle half of a signal for the operation of the printers the working margin of the system is therefore greatly increased.

57. We now must return to a further consideration of the corrector and its operation The corrector magnet is energized by the action of a separate piece of apparatus called a synchronizing unit. This consists of three neutral relays, together with associated condensers and resistances properly mounted, and wired as shown in Figure 13. A theoretical sketch showing its connections to the corrector relay and corrector is shown in Figure 14.

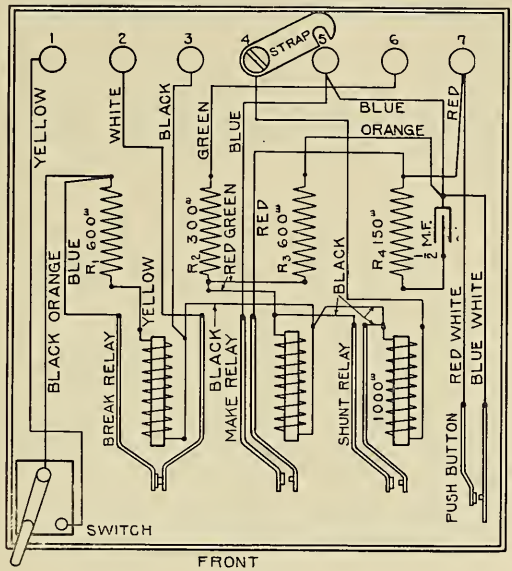



Fig. 13

58. Whenever the line current reverses from positive to negative the corrector relay closes on the marking contact. This completes a circuit from positive battery through the corrector relay contact and tongue through resistance R and the coil of the break relay to negative battery, thus operating the break relay. During the travel of its armature, and before the contacts of the break relay are opened, the current is divided at the point P and part of it completes a circuit through the contacts on the break relay to the solid corrector ring. Now, **if the corrector brushes are in such a position that they connect the solid ring with one of the A segments on the segmented ring** this circuit is carried still farther, either through what is known as the cam switch or in the case of segment 20A direct to resistance $R_1$ to point $P_1$, thence through two parallel circuits as follows: One through the coils of the make relay and to negative battery, thus operating this relay and closing its contacts, the other through the resistance $R_2$ and the coils of the shunt relay to negative battery. The impedance of the second circuit is very high compared to the first, however, so that sufficient current does not flow through this circuit to operate the shunt relay.

59. The closing of the make relay contacts establishes three circuits from positive battery:

(a) From positive battery through the closed contacts of the make relay and through resistance $R_2$ and the winding of the make relay to negative battery. This is a locking circuit which holds the make relay energized, and its contacts closed.

(b) From positive battery through the closed contacts of the make relay to the corrector magnet to negative battery. This energizes the corrector magnet, its armature closes, thus rotating the ratchet wheel through the action of the corrector pawl. As the ratchet wheel turns, the distributor brush shaft is rotated one and one-half degrees in a clockwise direction with respect to the motor armature, as already described.

(c) From positive battery through the closed contacts of the make relay through windings of the shunt relay to negative. This energizes the shunt relay, closes its contacts, which act as a direct shunt around the make relay.

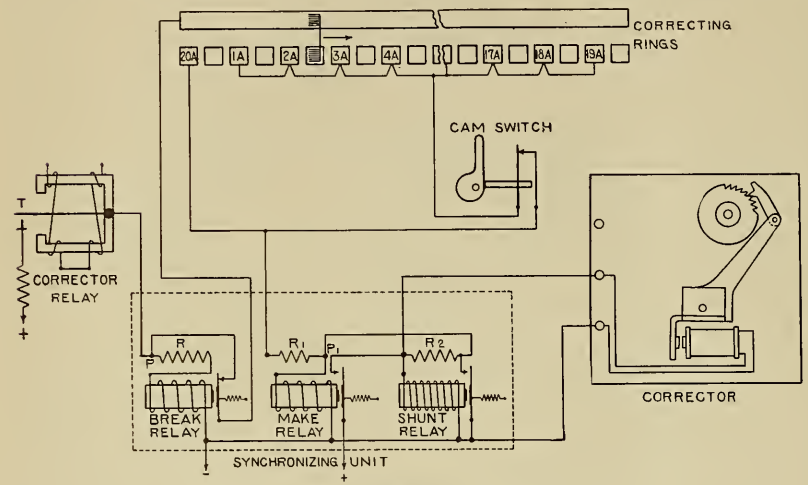



Fig. 14

60. The completion of this shunt by the closing of the shunt relay contacts diverts the current from the make relay windings and allows its armature to fall away, opening its contacts. This breaks the locking circuit through the make relay, which should now remain open or de-energized and also opens the circuit through the corrector magnet, allowing its armature to return to its normal position, ready to respond to the next correcting impulse.

61. The opening of the make relay contacts also de-energizes the shunt relay, which allows its armature to fall back and open its contacts, thus opening the shunt around the make relay winding, leaving it also in its normal condition, ready to respond to the next correcting impulse.

62. Let us now refer back to the heavy faced portion of paragraph 58. If instead of making contact between the solid ring and one of the A segments the brush connected the solid ring and one of the B segments we see immediately that the circuit which diverges at the point P is broken at the B segment. Therefore, under this condition, the make relay cannot close, consequently the corrector magnet is not energized and no correction can take place. In other words, whether or not the corrector operates when the line potential reverses from positive to negative depends upon the position of the corrector brushes AT THE MOMENT OF REVERSAL. If they are on an A segment the corrector will operate if on a B segment it will not operate.

63. From a consideration of this last statement, then, it becomes obvious that if we choose our phase relation, at the start, in such a manner that the reversal comes

when the correcting brush is in contact with one of the B segments, the corrector will not operate until the brushes at the correcting station creep up on an A segment, due to the fact that its distributor motor is purposely made to rotate a trifle faster than the non-correcting station's motor. When they do this the corrector operates, thus restoring the brushes to their correct position again.

**64.** To fix these facts clearly let us consider the respective positions of the sending segments at the non-correcting station, the correcting and receiving segments at the correcting station, the brush positions at both stations and the position of the transmitted wave in connection with Figure 15.

**65.** Four sending segments are shown developed at station X, which is the non-correcting station. A corresponding number of correcting and receiving segments is shown at Y, the correcting station. The transmitted wave is shown under the sending segments. This is shown as a square topped wave. At the receiving station this wave is shown, now slightly distorted, between the two sets of rings. When the brushes are all in the position shown on the line 1-1′-1″ (perfect phase relation) we see that the

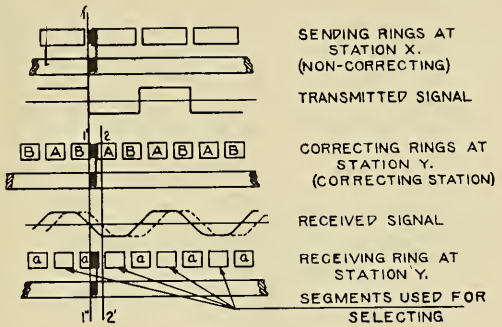



Fig. 15

correcting brush AT THE TIME OF REVERSAL is on a B segment. Consequently the corrector is not operated. If, however, the brushes at the receiving station get ahead of the sending brushes, as at the line 2-2′ (the received wave then assuming the position shown by the dotted line) the correcting brushes AT THE TIME OF REVERSAL are in contact with an A segment. Consequently the corrector operates and the brushes are returned to their proper position on the line 1′-1″ again. It should be noted that even at the extreme out of phase position of the brushes by the line 2-2′ the receiving segments are still in such a position that the selecting magnet receives a good steady impulse.

**66.** In the foregoing explanation in connection with Figure 15 it has been assumed that signals transmitted from the sending station were received simultaneously at the receiving station, but this is not exactly the case. Certain retarding influences act on the transmitted signals which tend to make the instant of reception slightly later than that of transmission. This difference in time may be equivalent to the time required for the brush to pass over a small fraction of a segment in case of short lines, or may be as much as the time required for passing over a full segment, or more, when the line is very long. Although this time difference in most cases is a small fraction of a second, it is large enough to affect the reception of signals, consequently some adjustment must be made to neutralize its effect. The elements responsible for this lag are the electrical inertia of the line and the electrical and mechanical inertia of the relays. The lag in the relays is caused by the impedance of their coils and the inertia of their armatures and tongues, and the time of transit of the tongues from one contact to the other. On most lines the lag caused by the relays is greater than that caused by the line itself.

67. For the purpose of illustration we will assume that the combined effect of these retarding influences may cause an impulse transmitted from segment number 2 of distributor X to be received on segment number 3 of the distant distributor Y; that is, the lag is assumed to be equivalent to one segment.

68. The effect is illustrated in Figure 16. The sending and receiving rings are developed horizontally for the sake of illustration. The brushes at the two stations are moving at the same rate of speed and in the same direction. The brushes at the sending station are passing over the second segment of the first quadrant and are, we assume, transmitting a marking signal to line. It will take time for this current to traverse the line and it will also take time for the relays at the receiving station to operate in response to the received signal. The brushes at the two stations are moving forward during this lapse of time, so that by the time the signal is received at the receiving station the brush at that station will have moved to the third segment. This will cause the signal transmitted from segment 2 at the sending station to be received on segment 3 at the receiving station, which will cause the third selecting relay of the receiving printer to be operated instead of the second, with the result that the receiving printer will perform the wrong function. It should be borne in mind that the position of the brushes at the receiving station is that which they will occupy at the beginning of the transmission of the signal from the sending station. The lag in this case is assumed to be the time of transit of the brushes over one segment.

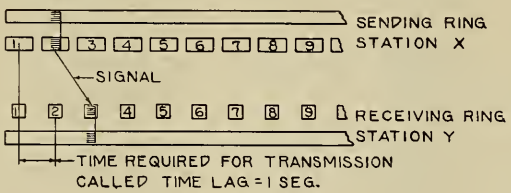

SENDING RING
STATION X
1 2 3 4 5 6 7 8 9
SIGNAL
1 2 3 4 5 6 7 8 9
RECEIVING RING
STATION Y
TIME REQUIRED FOR TRANSMISSION
CALLED TIME LAG = 1 SEG.

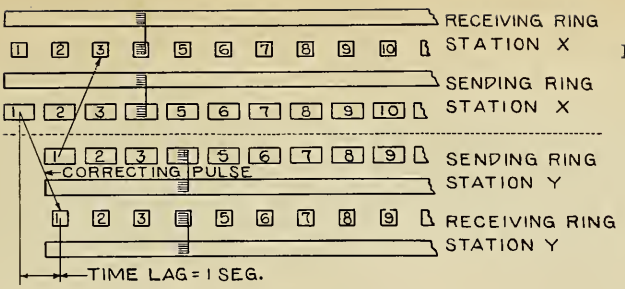
Fig. 16

69. If the station Y in Figure 16 is also the correcting station, this lapse of time is automatically compensated for when the two distributors are brought into step. In doing so, however, the sending segments at Y are even further displaced with respect to the receiving segments at X. We have then the condition represented in Figure 17A.

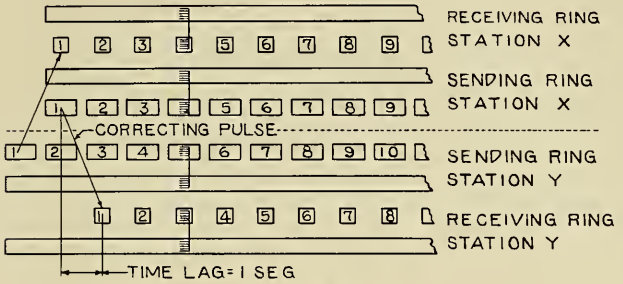
70. Here we represent both a section of the sending and receiving rings at each station. In starting the circuit the phase relation was so determined by the corrector that the time lag from the non-correcting station X is compensated for in the location of the receiving ring at the correcting station Y; that is, the impulse sent from segment 1 at X is so timed that it is received on the corresponding segment number 1 at Y. But now we find that the signal sent from sending segment 1 at Y is received on receiving segment 3 at X. So we have not only the time lag from Y to X, but the lag from X to Y is also reflected back on the non-correcting station X. To overcome this difficulty we must do one of two things: either move the sending ring segments ahead with respect to the other rings, or else move the receiving ring segments back with respect to the other rings.

71. We have previously mentioned the fact that the receiving ring is not rigidly connected to the other rings. By rotating this ring counter-clockwise a certain small amount of lag may be taken up.

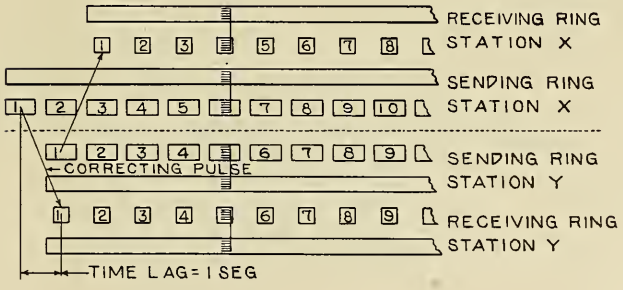
72. When the lag is more than can be taken care of in this manner it must be taken up by displacing the sending ring with respect to the receiving ring. As mentioned earlier in the text the plug which connects the sending ring of the face plate to the distributor table wiring may be removed from the connecting block and rotated one or more pins in the counter-clockwise direction and placed into the socket in that position. If it


RECEIVING RING
STATION X
SENDING RING
STATION X
SENDING RING
STATION Y
CORRECTING PULSE
RECEIVING RING
STATION Y
TIME LAG = 1 SEG.

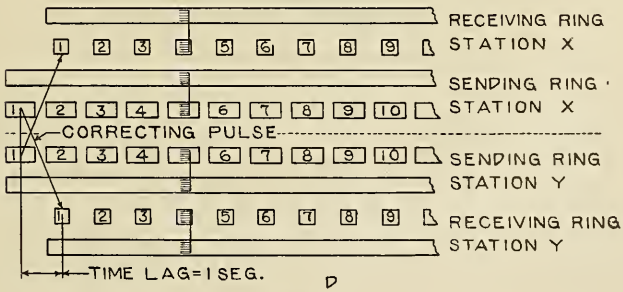
A


RECEIVING RING
STATION X
SENDING RING
STATION X
CORRECTING PULSE
SENDING RING
STATION Y
RECEIVING RING
STATION Y
TIME LAG = 1 SEG

B


RECEIVING RING
STATION X
SENDING RING
STATION X
CORRECTING PULSE
SENDING RING
STATION Y
RECEIVING RING
STATION Y
TIME LAG = 1 SEG

C


RECEIVING RING
STATION X
SENDING RING
STATION X
CORRECTING PULSE
SENDING RING
STATION Y
RECEIVING RING
STATION Y
TIME LAG = 1 SEG.

D

Fig. 17

is rotated the distance of one pin, segment 20 on the face plate will be connected to the socket formerly occupied by segment 1. This rotation of the sending plug is therefore equivalent to moving the sending ring segments ahead one segment with respect to the receiving segment so that a signal will be transmitted from segment 1 while a signal from the distant station is being received on receiving segment 20. In this manner lag may be taken up at either the correcting station as shown in 17B or the non-correcting station as shown in 17C, or at both stations as shown in 17D.

73. When it is necessary to take up only one or two segments lag, any one of these three methods is satisfactory. When more than this amount is taken up it should be done at both stations as shown in Figure 17D. The reason for this rule is that the fixed relationship between the position of the sending segments and the local segments which operate the transmitters is decreased when the sending ring is displaced. If all the lag were taken up at one station this relationship might be decreased to the point where the moment of transmission follows so closely upon the operation of the transmitter magnet that the contacts of the transmitter may not have had a sufficient time to settle down to a firm contact before the brushes pass over the sending segments connected to these contacts. By dividing the amount of lag taken up between the two stations the maximum lag usually encountered can be taken up without difficulty.

74. We have mentioned the fact that the proper phase relationship is determined when the circuit is started, but we have not yet attempted to describe the means for obtaining this relationship. Obviously some way must be provided so that it is possible to place segment 1, for instance, at the correcting station in correspondence with the same segment, plus the line lag, at the sending station. The cam switch is an aid in securing this relationship.

75. The cam switch is a multiple switch constructed as shown in Figure 18. It performs the following functions:

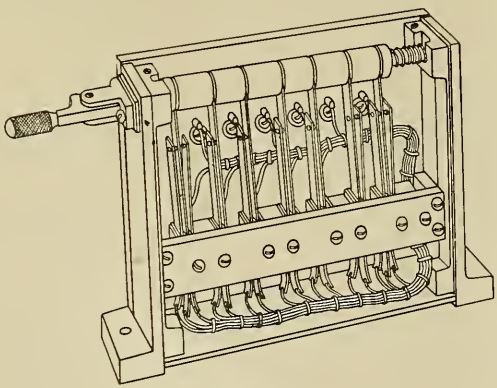


Fig. 18

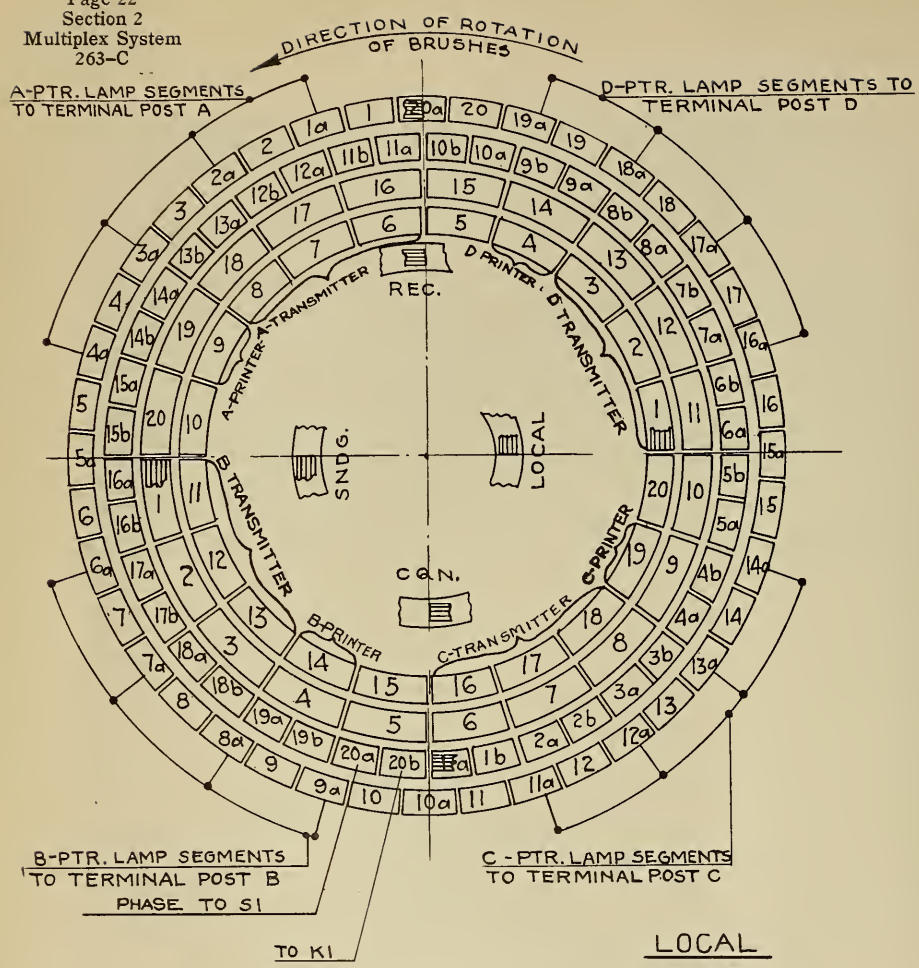
(a) Stops all transmitters.
(b) Connects positive battery to all sending segments except number 20, which is negative.
(c) Opens the connection between the synchronizing unit and correcting segments 1A to 19A inclusive, leaving only 20A connected to this unit.

76. With the switch in its "off" position, then only one correcting impulse can be sent out from the sending station per revolution of the distributor brushes. This correcting impulse comes when the brush passes from positive battery on segment 19 to negative

battery on segment 20. The corrector at the correcting station can work only when this correcting impulse falls on correcting segment 20A, this being the only segment connected to the synchronizing unit. It is therefore evident that if the corrector is made to operate with the cam switches at both terminals in their off position the proper relationship will exist between the two distributors.

77. The actual circuits controlled by the cam switch will be taken up in the section devoted to terminal apparatus.

78. Before leaving the subject of the Distributor and its Associated Parts mention must be made of the different distributor face plates. So far in these specifications we have described only four channel apparatus. The Multiplex, as has already been mentioned, may be used with one, two, three or four channels, however, without changing any of the fundamental apparatus. The distributor face plates must, however, be changed. As may be surmised, only three-fourths as many segments are needed should we wish to use only three channels; half as many if we wish to use only two channels. By the same reasoning we would expect to have only one-fourth as many for a one-channel set, but in practice the one-channel circuit is really a two-channel set where one channel is left idle so the one channel set uses the same number of segments as the two-channel set. In mechanical construction the two and single channel head is exactly like the four channel head but electrically it has only half as many segments; i. e., the segments are strapped together in pairs. Figures 19, 20 and 21 show the layout and wiring of the three different face plates.



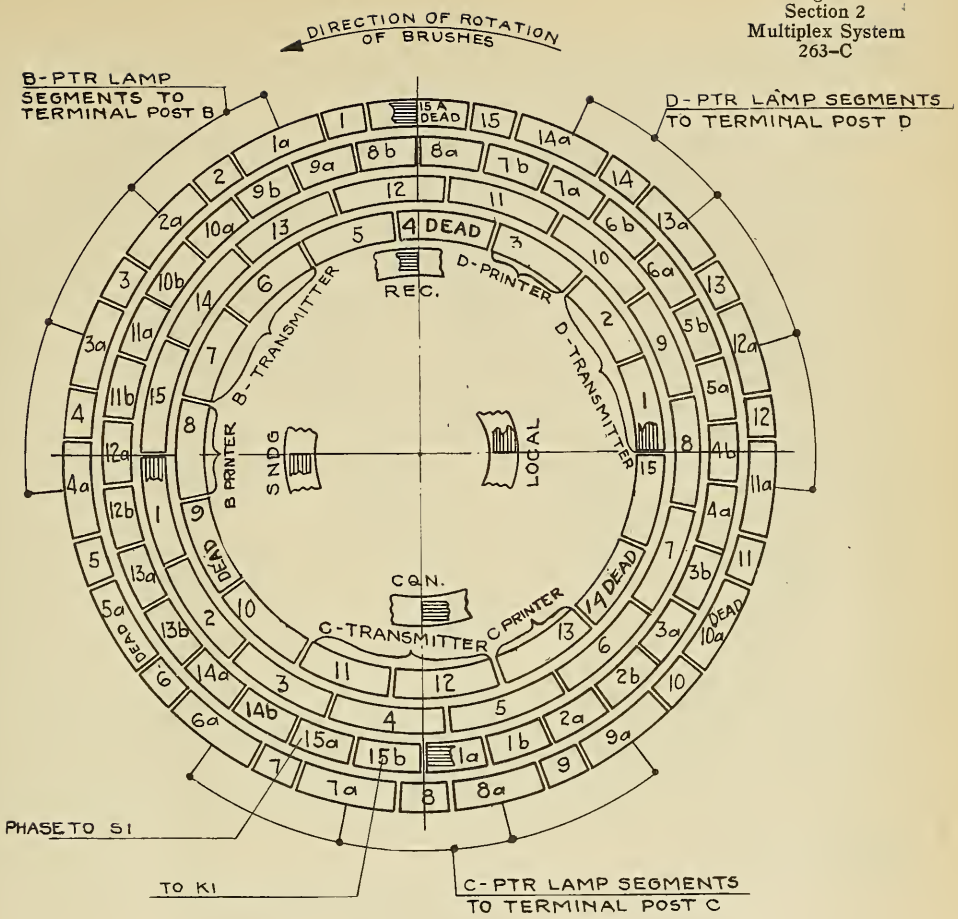

## SEGMENTS

| RECEIVING | CORRECTING | SENDING |
|---|---|---|
| 1-20 TO PLUG PINS 1-20. | 18-19B TO PLUG PIN K19. 1a-19a TO PLUG PIN S19. | 1-20 TO PLUG PINS 1-20. |

Fig. 19

## LOCAL

| | | | | |
|---|---|---|---|---|
| 1 | TO | PLUG | PIN | 4 |
| 2 | " | " | " | 5 |
| 3 | " | " | " | 6 |
| 4 | " | " | " | 3 |
| 5 | " | " | " | 7 |
| 6 | " | " | " | 9 |
| 7 | " | " | " | 10 |
| 8 | " | " | " | 11 |
| 9 | " | " | " | 8 |
| 10 | " | " | " | 12 |
| 11 | " | " | " | 14 |
| 12 | " | " | " | 15 |
| 13 | " | " | " | 16 |
| 14 | " | " | " | 13 |
| 15 | " | " | " | 17 |
| 16 | " | " | " | 19 |
| 17 | " | " | " | 20 |
| 18 | " | " | " | 1 |
| 19 | " | " | " | 18 |
| 20 | " | " | " | 2 |

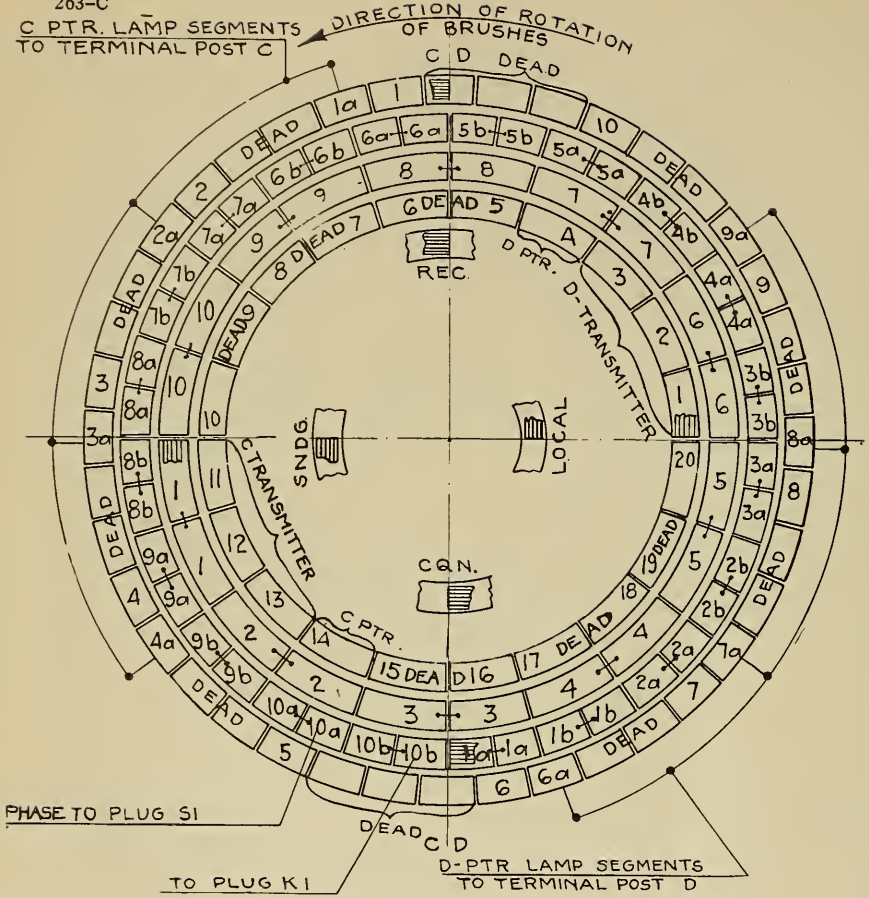



## SEGMENTS

| RECEIVING | CORRECTING | SENDING |
|---|---|---|
| 1-15 TO PLUG PINS 6-20. | 1B-14B TO PLUG PIN K19, 1a-14a TO PLUG PIN S19. | 1-15 TO PLUG PINS 6-20. |

Fig. 20

| LOCAL | | | | |
|---|---|---|---|---|
| 1 | TO | PLUG | PIN | 4 |
| 2 | " | " | " | 5 |
| 3 | " | " | " | 3 |
| 5 | " | " | " | 12 |
| 6 | " | " | " | 14 |
| 7 | " | " | " | 15 |
| 8 | " | " | " | 13 |
| 10 | " | " | " | 17 |
| 11 | " | " | " | 19 |
| 12 | " | " | " | 20 |
| 13 | " | " | " | 18 |
| 15 | " | " | " | 2 |




NOTE:
FOR SINGLE OPERATION "C" IS NOT USED

## SEGMENTS

| RECEIVING | CORRECTING | SENDING |
|---|---|---|
| 1-10 TO PLUG PINS 11-20. | 1B-9B TO PLUG PIN K19.<br>1a-9a TO PLUG PIN S19. | 1-10 TO PLUG PINS 11-20. |

Fig. 21

| LOCAL | | | | |
|---|---|---|---|---|
| 1 | TO PLUG | | PIN | 4 |
| 2 | " | " | " | 5 |
| 3 | " | " | " | 6 |
| 4 | " | " | " | 3 |
| 10 | " | " | " | 17 |
| 11 | " | " | " | 19 |
| 12 | " | " | " | 20 |
| 13 | " | " | " | 1 |
| 14 | " | " | " | 18 |
| 20 | " | " | " | 2 |

## ADJUSTMENTS

1. **General.** Before adjusting, the apparatus shall be thoroughly cleaned, examined for mechanical or electrical defects, and a thin film of oil placed on all bearings surfaces. Ball bearings shall be packed with a good quality non-fluid oil such as the New York and New Jersey Lubricant Company's No. K-OO Special Non-Fluid Oil. The collector ring brushes on the distributor corrector shall be kept clean and free in their sockets.

## DRIVING FORK ADJUSTMENTS

2. **Contacts.** The driving fork contacts shall be adjusted as shown in Figure 22.

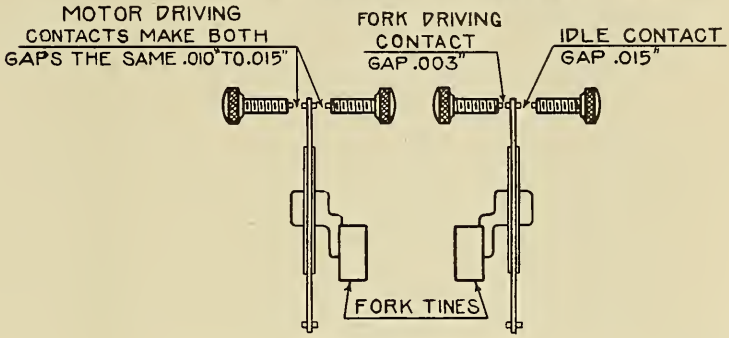



Fig. 22

This adjustment is made with the aid of a thickness gauge, while the fork is at rest. Note that the driving contact adjustment may be from .010 to .015 inch, but that both gaps must be the same. If they are, the mil-ammeter shown in Figure 3, known as the fork meter, will read zero when the fork and motor are placed in operation. Should this meter show a deflection to either side of zero when the distributor is running, the adjustment or the driving contacts shall be refined until the meter reads zero. The reinforcing spring and clamp shall be located in the center of the contact springs in the mounting.

3. **Polepieces.** The distance between the magnet polepieces and the tines of the fork shall be 1/8 inch. Care shall be taken to keep the face of the polepieces parallel to the tines of the fork. Figure 23 illustrates the method of making the adjustment.

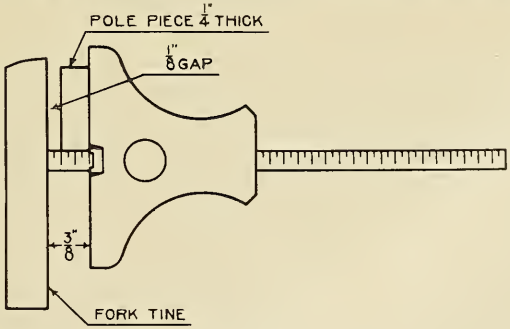



Fig. 23

4. **Speed.** Adjustment for speed is made with the weights furnished with the fork, the position of the weights for any given speed being obtained from the graph given in Figure 24.

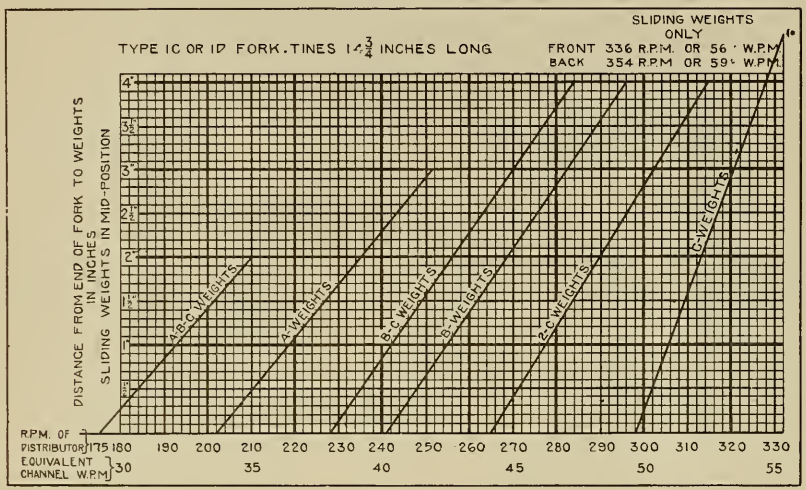

SLIDING WEIGHTS ONLY
FRONT 336 R.P.M. OR 56 W.P.M.
BACK 354 R.P.M. OR 59 W.P.M.
TYPE IC OR ID FORK. TINES 14 3/4 INCHES LONG
DISTANCE FROM END OF FORK TO WEIGHTS IN INCHES
SLIDING WEIGHTS IN MID-POSITION
4"
3 1/2"
3"
2 1/2"
2"
1 1/2"
1"
1/2"
A-B-C WEIGHTS
A WEIGHTS
B-C WEIGHTS
B WEIGHTS
2-C WEIGHTS
C WEIGHTS
R.P.M. OF DISTRIBUTOR 175 180 190 200 210 220 230 240 250 260 270 280 290 300 310 320 330
EQUIVALENT CHANNEL W.P.M. 30 35 40 45 50 55

Fig. 24

5. **Rubber Feet.** Care shall be taken to keep the rubber feet of the fork in good condition. When these feet become worn so that the fork rests upon the metal screws rather than the rubber, some of the energy of the fork is transmitted through them to the table, thus decreasing the amplitude of the fork's vibration.

## DISTRIBUTOR ADJUSTMENTS

6. **Brushes.** The distributor brushes shall be set with the aid of the brush jig furnished with the distributor as shown in Figure 25. The brush arms shall be placed on the jig, as shown, with the guide pin through the hole in the first arm. The ends of each brush shall first be cut off squarely and the brush curved to form an arc so that if it is rested on its two ends on a flat surface the center of the brush will be 1/8 inch above the surface. After this is done they shall be placed in the holders concave side against the bottom of the brush groove so that they lie perfectly flat when tightened, with the trimmed end of the brushes just touching the guide lines on the jig. The thumbscrews shall be tightened only with the fingers.

7. **Brush Holder Bearing.** The brush holder bearing shall be placed on the distributor shaft as shown in Figure 26. The distance from the face plate to the shoulder of the brush holder bearing shall be 11/32 inch. This adjustment gives the proper brush tension if the brushes have been properly set as directed in Paragraph 6.

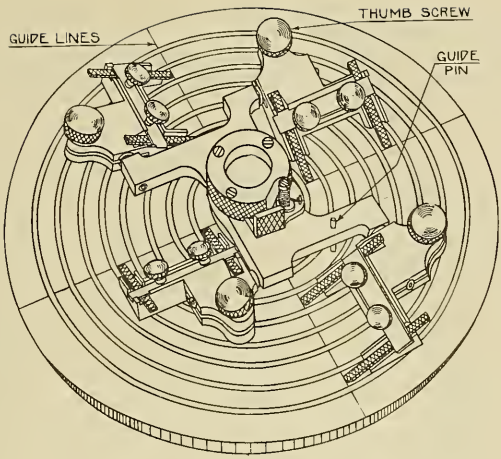



Fig. 25

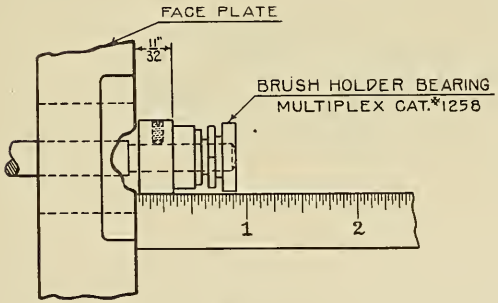



Fig. 26

## DISTRIBUTOR CORRECTOR ADJUSTMENTS (FIG. 27)

8. Release the jockey roller, also the pawl, from the ratchet wheel. Revolve the flywheel in one direction and rotate the distributor brush shaft in the other direction to make certain that the gears run entirely free from any mechanical friction due to poor alignment of the shafts, etc.

9. **Armature Stop Screw.** Raise the stop plate so that the armature can be pressed firmly in contact with the core of the magnet. With the armature in this position adjust the stop screw so that the armature will have .040 inch travel between the core and stop screw. Secure this adjustment with the lock nut.

10. **Jockey Roller Bearing Block.** Return the pawl to its normal position and put enough tension on the jockey so that it will hold the ratchet wheel firmly while the next adjustment is made. Now adjust the jockey roller bearing block laterally very care-

fully so that the armature must move .010 inch away from the stop screw before the pawl engages a tooth on the ratchet wheel.

11. **Jockey Roller Tension.** Remove the armature return spring and adjust the tension on the jockey roller so that a force of 600 grams applied as shown by the arrow in Figure 27 will just operate the corrector.

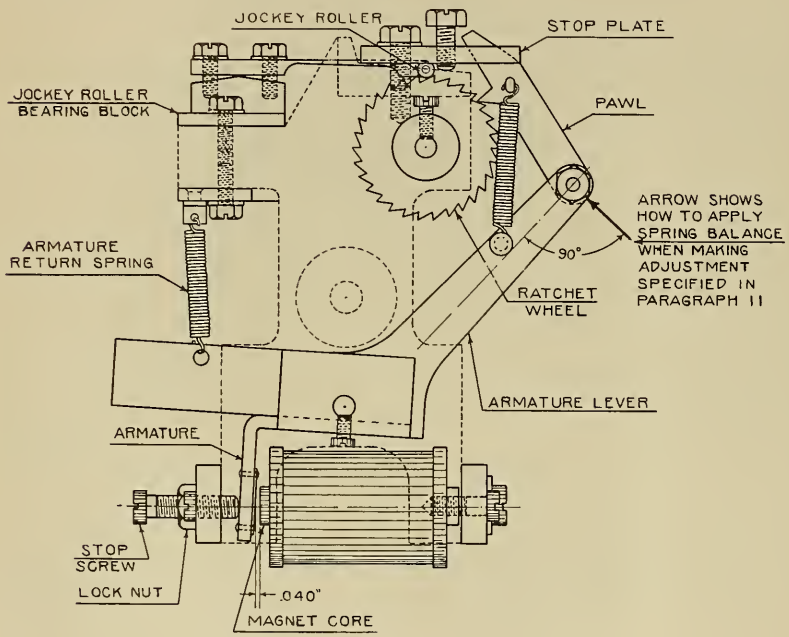



Fig. 27

12. **Armature Return Spring.** Replace the armature return spring. This spring in its normal position should have a tension of approximately 550 grams.

13. **Pawl Spring.** Adjust the pawl spring to hold the pawl against the ratchet with a minimum force of 75 grams.

14. **Stop Plate.** Lower the stop plate as far as possible without permitting the pawl to stop on it. Make sure there is no friction between the pawl and the slot in the stop plate.

15. All adjustments should be very tight or the frequent operation of the corrector as well as its rotation will otherwise work them loose.

## SYNCHRONIZING UNIT ADJUSTMENTS

16. **Break Relay Armature Backstop.** Adjust the armature backstop so that there is a clearance of .025 inch between the armature and the magnet core.

17. **Break Relay Contact Spacing.** With the relay de-energized and its armature resting against the backstop, adjust the contacts so that there is a clearance of .010 inch

between the fibre stud of the armature and the contact spring. The stationary contact spring shall have sufficient tension to hold it rigidly against the head of the magnet spool.

18. **Break Relay Contact Spring Tension.** Connect some convenient source of current to binding posts 1 and 3 of the unit, close the switch in the base, and adjust the spring tension of the relay so that a current of .031 ampere will not operate the relay but a current of .035 ampere will.

19. **Make Relay Backstop.** Adjust the backstop on this relay so that there is a clearance of .010 inch between the armature and the polepiece.

20. **Make Relay Contact Spacing.** The outside spring shall be held firmly against the head of the spool at all times, and the inner spring shall make contact with the outer one when the armature is moved to a position .003 inch from the polepiece.

21. **Make Relay Contact Spring Tension.** Connect the test circuit to binding posts 3 and 6 and adjust the spring tension so that the relay will operate on .024 ampere but not on .020 ampere.

22. **Shunt Relay Backstop.** Adjust the backstop so that there is a clearance of .026 inch between the armature and the polepiece.

23. **Shunt Relay Contact Spacing.** The outside contact spring shall be held firmly against the head of the spool, and the inner spring shall make contact with the outer one when the armature is moved to a position .012 inch from the polepiece.

24. **Shunt Relay Contact Spring Tension.** Remove the strap which connects binding posts 4 and 5, and connect the test circuit to binding posts 3 and 4. Adjust the spring tension so that the relay will operate on .044 ampere but not on .040 ampere.

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 3

TRANSMITTER 1-A

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These Specifications are the property of the Western Union Telegraph Company and shall not be published.

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CONTENTS


| Subject | Paragraph |
|---|---|
| GENERAL DESCRIPTION | 2 |
| CONSTRUCTION | 5 |
| OPERATION | 7 |
| STOPPING THE TRANSMITTER | 10 |

SPECIFICATIONS INCLUDED: None.

PHOTOGRAPHS AND DRAWINGS:

| Figure No. | Drawing No. | Title |
|---|---|---|
| 1 | Photograph | Transmitter 1-A. |
| 2 | 22341- -1 | Transmitter 1-A. |
| 3-A-B | 22342- -1 | Transmitter Stop Latch Mechanism. |
| 4 | 22344- -1 | Transmitter 1-A Wiring Diagram. |
| 5 | 22345- -1 | Transmitter Feed Wheel Adjustment. |
| 6 | 22346- -1 | Transmitter Jockey Spring Adjustment. |
| 7 | 22347- -1 | Transmitter Selecting Pin Adjustment. |
| 8 | 22348- -1 | Transmitter 1-A Armature Adjusting Plate Adjustment. |
| 9 | 22349- -1 | Support Lever Spring Adjustment. |

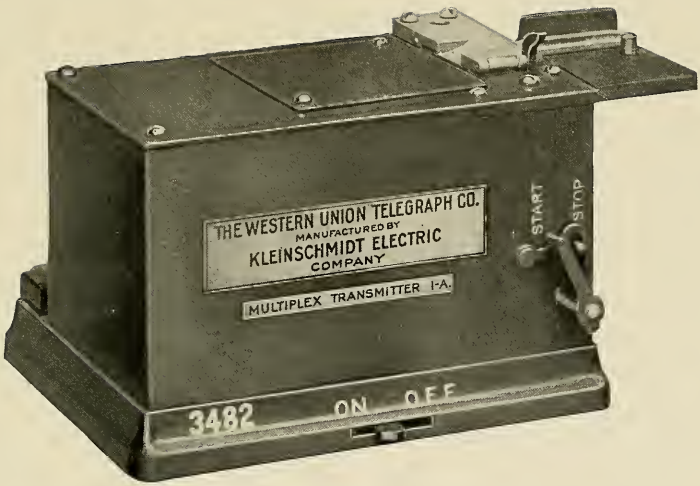
THE WESTERN UNION TELEGRAPH CO.
MANUFACTURED BY
KLEINSCHMIDT ELECTRIC
COMPANY
MULTIPLEX TRANSMITTER I-A.
START
STOP
3482
ON
OFF

Fig. 1

## MULTIPLEX TRANSMITTER 1-A

1. The transmitter (Fig. 1) as described in Section 1 is an electrically operated device for setting up on the distributor segments the combinations of positive and negative impulses, corresponding to the various characters previously prepared on a paper tape for transmission to the line.

2. This transmitter consists of five tongues connected mechanically to five pins or selecting rods. Each tongue is connected to a segment of the transmitting ring of the distributor, and moves between two contact points, one of which is connected to the marking terminal of the line battery, the other to the spacing terminal. Normally all pins tend to move upward by the force of a spring and consequently to move their linked tongues to the marking stop. When, however, a perforated tape is fed along the top of the transmitter and over the selecting pins, only those pins which are directly opposite a perforation in the tape can continue their upward travel through the perforation. Therefore only these can move their tongues to the marking stop, the other pins, being stopped by the web of the tape, cause their tongues to remain on the spacing stop.

3. The prepared tape passes over the pins from right to left and is fed forward one character at a time (1/10 of an inch). The feeding of the tape is effected by means of a small star-wheel, the teeth of which engage in the feed holes of the tape. The selecting pins and star-wheel are operated by an electromagnet which is energized by a local battery once for each revolution of the brush arm of the distributor. This magnet attracts its armature, which in turn withdraws the pins from the perforations in the tape and moves the five tongues to the spacing contacts and at the same time, just as the pins have cleared the perforation feeds the tape forward one character combination or 1/10 of an inch. When the armature is released the five pins move upward, by means of a spring on each pin, against the perforated tape. The pins in line with the perforations in the paper tape will pass through, causing the corresponding tongue or tongues, as the case may be, to move against the contacts to which the marking battery is connected, while those pins which are stopped by the web of the tape hold their tongues against the contacts to which the spacing battery is connected. A combination of positive and negative polarities is thereby set up on the distributor segments to which the corresponding tongues are connected. These different polarities are transmitted to line as impulses when the distributor brushes pass over these segments. On the next revolution of the distributor brushes the local current again passes through the electromagent of the transmitter and the operation described is repeated for the next character or function.

4. With this general description let us refer to Figure 2 which shows the automatic transmitter stripped of all but the essential transmitting parts, and follow the operation in connection with the operating segment of the distributor. The rings of the distributor, for simplicity, are shown developed or rolled out.

5. The five tongues of the transmitter are electrically connected to five consecutive segments on the sending ring. They are mechanically mounted on the pivoted support levers in such a manner that the tongues may be brought into contact with either the marking or spacing contacts by a slight rotation of the support levers. The free end of the support levers is held against a step on the selecting pins by the support lever springs. The lower end of the selecting pins rests on the spring levers; the upper end protrudes through holes in the tape guide. (Tape guide not shown.) Through the action of the selecting pin bar springs the pins are normally forced upward, thus rotating the support levers until the tongues touch the marking contacts. This limits the upward motion of the selecting pins.

6. A plate is so mounted on the magnet armature that it will engage steps on the selecting pins and pull them down whenever the magnet is energized. The armature also operates the feed pawl through the pivoted feed rocker and sliding bar. This feed pawl engages a ten toothed ratchet wheel forming part of the feed wheel shaft. Each opera-

tion of the magnet therefore causes the feed wheel to be rotated through an angle of 36 degrees. This advances the tape one-tenth of an inch, which is the distance between two consecutive feed holes. A spring, not shown in the drawing, holds the feed magnet armature away from the pole pieces when the magnet is not energized.

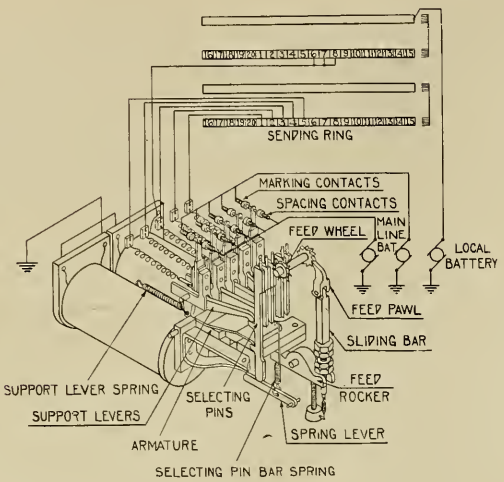


Fig. 2

7. Keeping in mind this description of the different parts of the instrument, let us follow through the operation of the transmitter during one revolution of the distributor brushes. Let us assume that the letter A combination is directly over the pins of the transmitter.

8. As the brushes move from left to right they do not affect the operation of this particular transmitter until the sending brushes are making contact between sending segment 1 and the solid ring. At this point an impulse is sent to the line, and since in the letter A there is a perforation directly above the first pin this selecting pin has moved up, thus moving the tongue controlled by lever 1 to the left hand stop. The line impulse sent out is therefore marking battery. When the brush reaches the second sending segment the battery is not reversed, for the second pin has also moved up through the perforation above it in the tape and has moved its tongue to the marking contact. When the brush passes to the third segment, however, the battery is reversed, for there is no perforation above the third pin, hence the third tongue is still in contact with the right hand contact, which is connected to the spacing battery. The fourth and fifth segments also send out spacing battery in the same manner as the third.

9. The local brushes next come in contact with segments 6-7-8, which are strapped together to provide an impulse of sufficient duration to properly operate the feed-magnet. This magnet is energized. The armature plate engages the steps on the selecting pins and draws them away from the paper tape. When they are out of the way the feed pawl rotates the feed wheel shaft, thus advancing the tape one feed hole. When the brush finally leaves segment 8 the magnet is de-energized, thus permitting the feed pawl to drop back to its normal position. The selecting pins are also released by the armature

plate so that those pins which are directly under perforations in the tape, in its new position, may move up, thus moving their tongues to the marking contact as described. The transmitter is now ready to send out the new combination on the next revolution of the brushes.

10. To provide a convenient means of stopping the transmitter with the tongues on the spacing contacts a manually controlled locking device is provided. This consists of an extension on the armature which is provided with a small hook so arranged that it may be engaged by a latch controlled by a lever extending outside the transmitter cover.

11. When this lever is in the position shown in Figure 3A the latch is thrown to the right, away from the hook on the end of the armature extension. If, however, the lever be thrown to the position shown in Figure 3B the spring pulls the latch into engagement with the hook and prevents further upward motion of the extension, and the armature therefore remains locked in its operated position.

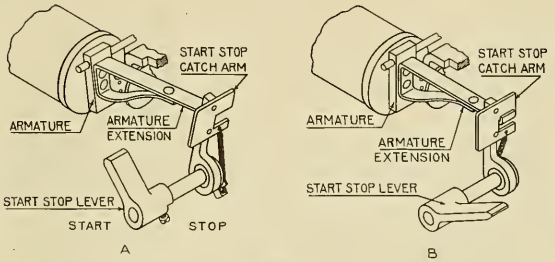


Fig. 3

12. A switch is also provided in the base of the transmitter by means of which the circuit through the feed magnet may be opened. This switch is shown in the transmitter circuit diagram, Figure 4.

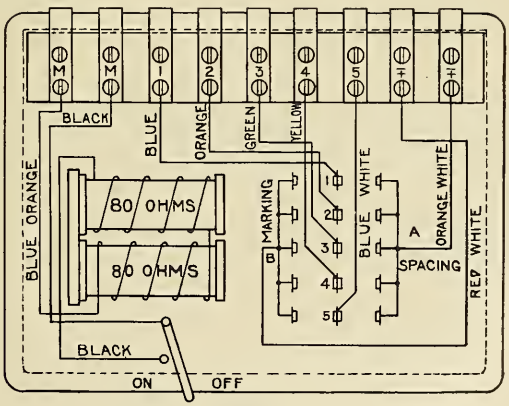


Fig. 4

## ADJUSTMENTS

1. **General.** Before adjusting, the apparatus shall be thoroughly cleaned, examined for mechanical or electrical defects, and a thin film of oil applied to all bearing surfaces.

2. **Feed Wheel Position.** The horizontal distance from the center of the feed wheel pins to the center of the selecting pins shall be .287 inch. To measure this distance the transmitter gauge, tool No. 162, shall be used, as shown in Figure 5. To increase the distance loosen the lower adjustment screw (Fig. 6) on the jockey lever and tighten the upper one; to decrease the distance loosen the upper and tighten the lower screw.

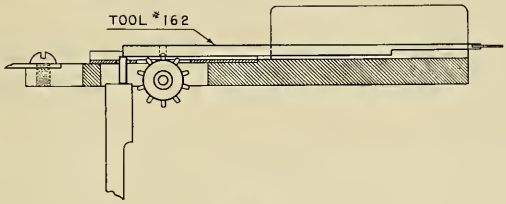


Fig. 5

3. **Jockey Roller Spring.** The tension of the jockey roller spring shall be 100 grams, measured as shown in Figure 6.

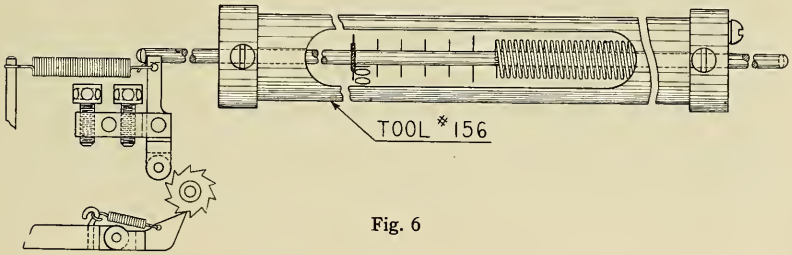


Fig. 6

4. **Sliding Bar Lower Adjusting Nuts.** Set the lower nuts on the sliding bar so that the feed pawl has stroke enough to carry the ratchet tooth just sufficiently beyond the center of the jockey roller to permit the roller to complete the stopping of the feed wheel. This adjustment must be very carefully made and the lock nut carefully tightened; otherwise it will interfere with the selecting pin adjustment.

5. **Sliding Bar Upper Adjusting Nuts.** The upper nuts shall be set so that there is a clearance of .015 inch between the upper nut and the slide bearing when the magnet armature is held against the magnet core.

6. **Feed Rocker.** Adjust the feed rocker by setting its stop screw so that the feed pawl will clear the ratchet tooth by .015 inch when the magnet armature is in its released position.

7. **Marking Contacts.** Adjust the marking contact screws so that when the magnet is not energized the selecting pins will protrude .044 inch above the tape guide. Use tool No. 162 as shown in Figure 7.

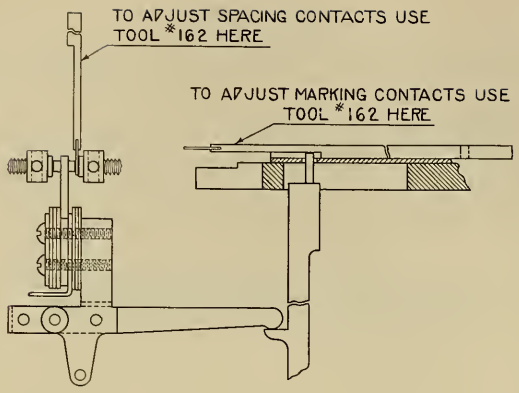


Fig. 7

8. **Spacing Contacts.** Adjust the spacing contacts so that there is a gap of .006 inch between the contact screws and their tongues. See Figure 7.

9. **Armature Adjusting Plate.** Hold the magnet in its operated position and adjust the armature adjusting plate so that there is a clearance of .078 inch between the upper steps on the selecting pins and the support levers. Use tool No. 162 as shown in Figure 8.

10. **Armature Back Stop.** Release the magnet armature and adjust the armature stop screw so that there is a clearance of about .020 inch between the armature adjusting plate and the top of the lower step on the selecting rods. The tension of the armature retractile spring shall be sufficient to just pull the armature firmly against the stop screw when the armature is released slowly by hand.

11. **Tongue Pressure Against the Spacing Contacts.** Lock the feed magnet by means of the stop latch in its stop position. Raise the tape latch and apply the scale as shown in Figure 9. Adjust each support lever spring by means of its spring adjusting plate so that the scale will read 1 ounce when the tongue breaks contact with the spacing contacts.

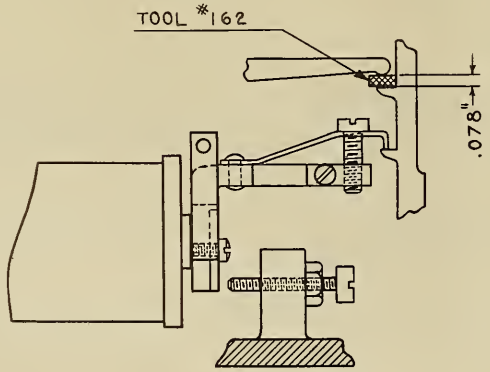


Fig. 8

12. **Tongue Pressure Against the Marking Contacts.** Release the stop latch and allow the tongues to come to rest on their marking contacts. Now use the scale in the same way as before and adjust each selecting pin bar spring by means of its selecting pin spring hanger adjusting screw until 1 ounce is required to break the contact on the marking contacts.

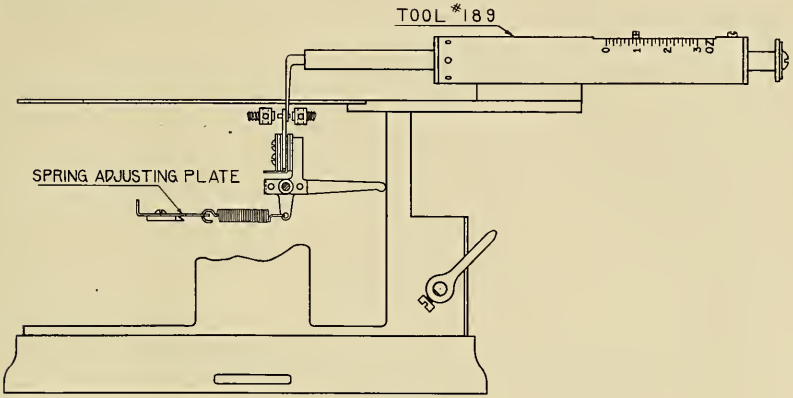


Fig. 9

13. **Manual Stop Latch.** The latch of the manual stop and start mechanism is arranged to hook over the extension on the armature when the magnet is energized and the armature drawn down against the pole pieces. The upper edge of the slot in the latch shall be adjusted to pass over the hook on the end of the extension with a clearance of about .005 inch. This adjustment must be made, whenever necessary, by bending the armature extension.

14. **Tape Guide.** The tape guide shall be so located that the tape passes through without pressure on either edge. The tape guide may be moved forward or backward a short distance when necessary. Excessive side play of the tape may be due to a worn tape guide or too narrow tape.

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 4

PERFORATOR 1-A

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These Specifications are the property of the Western Union Telegraph Company and shall not be published.

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SPECIFICATIONS INCLUDED: None.

PHOTOGRAPHS AND DRAWINGS:


| Figure No. | Drawing No. | Title |
|---|---|---|
| 1 | Photograph | Perforator 1-A. |
| 2 | 4583- -1 | Keyboard Layout. |
| 3 | 22354- -2 | Key Levers and Selecting Mechanism. |
| 4 | 22312- -1 | Specimen of Perforator Tape. |
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| 8 | 22357- -1 | Wiring Diagram. |
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| 10 | 22358- -1 | Key Lever and Selecting Bar Stop. |
| 11 | 22359- -1 | Method of Gauging Tape. |

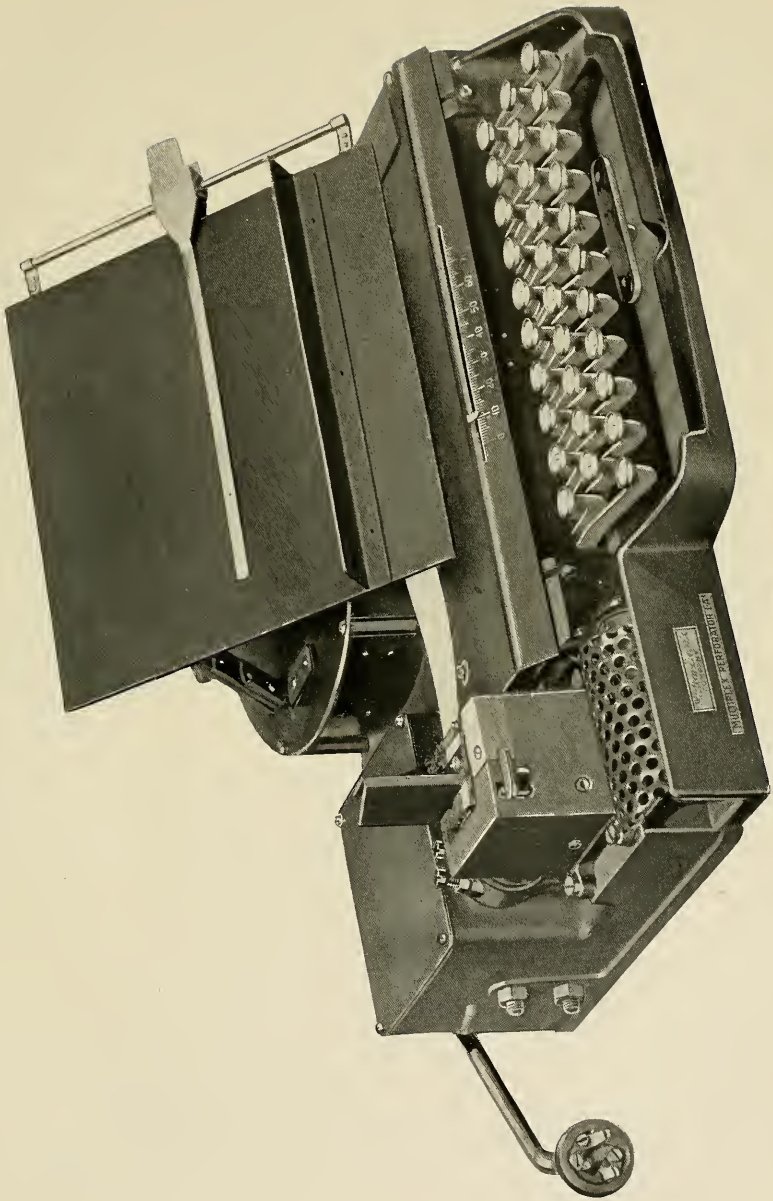

Fig. 1

## MULTIPLEX PERFORATOR 1-A

1. Keyboard perforator 1-A is a device controlled by a typewriter keyboard for perforating holes in a paper tape to form the characters representing in the Multiplex alphabet the message to be transmitted.

2. Its essential parts are:

(a) A punch block containing a die plate and six punches comprising one for punching the small feed holes, and five for punching selecting holes that determine the character to be transmitted. The paper tape passes through this punch block.

(b) A magnetically operated punch hammer which forces the punches through the tape.

(c) A system of five selecting levers that may be inserted between the punch hammer and the punches so as to determine which of the five selecting holes shall be perforated.

(d) A typewriter keyboard by means of which the selecting levers and punch magnet are controlled.

(e) A device for feeding the punched tape.

3. The keyboard is arranged as shown in Figure 2. There are thirty-one keys and a space bar. Twenty-six of the keys have the letters of the alphabet on the lower case; figures or punctuation marks, etc., on the upper case. One key, marked FIGS, represents the signal which causes the printer to shift to the upper case. After it is depressed all the combinations following represent upper case characters until the key marked LTRS is depressed. This key represents the signal which restores the printer to the lower case. The key marked CAR RET represents the signal which causes the printer carriage to return to such a position that the printing will be started at the left hand margin of the paper, and the one marked LINE FEED represents the signal that causes the printer to feed the paper up to a new line. The space bar represents the signal that causes the printer to make the space between words. One key is blank and perforates only feed holes.

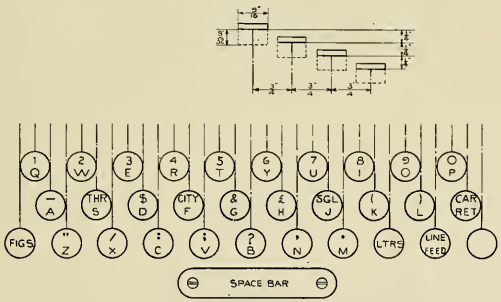


Fig. 2

4. The key levers are pivoted at the inner end to the frame and held up against a stop by spiral springs, which are adjustable.

5. Directly under, and at right angles to the key levers, are five selecting bars and one contact bar. The five selecting bars determine which of the five punches are to be operated; the contact bar controls the operation of the contact which energizes the punch magnet.

6. The key levers operate one or more of these bars by means of lugs on their under edge, thereby determining which punches shall be operated.

7. As seen from Figure 3 the selecting and contact bars are not pivoted, but slide on rollers along inclined planes punched in the bars themselves. When a key is depressed and one or more of the bars are operated they are given a right hand, as well as a downward, movement. This right hand movement operates the selecting links, which in turn impart to the selecting fingers a left hand movement. When so moved the tips of the selecting fingers are placed directly under their corresponding punches.

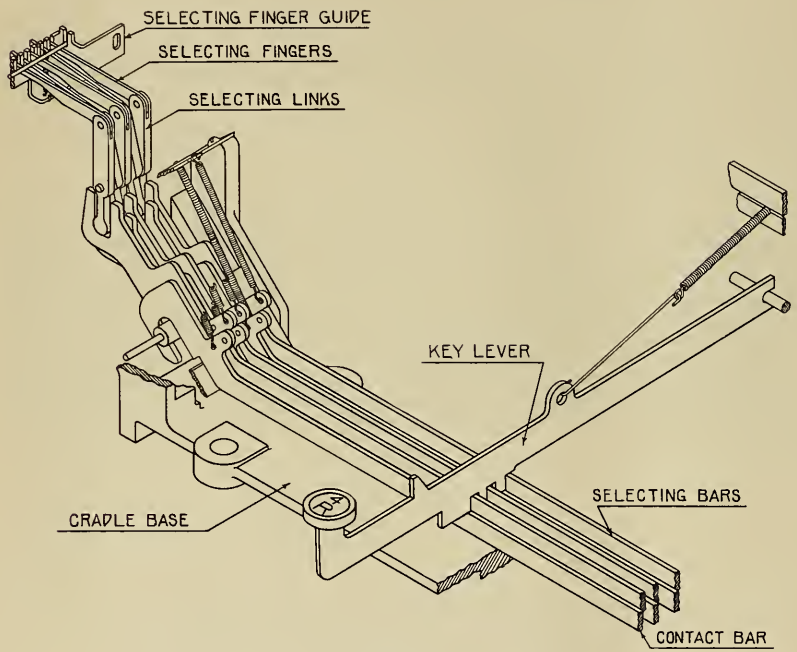


Fig. 3

8. The punches are assembled into the punch block. There are five punches used for punching the letter or character combinations, and one punch for punching the feed holes in the tape. This punch is of a smaller diameter but somewhat longer than the other punches.

9. The punches are held away from the die plate by springs. There is a small wire spring for each punch, and in addition a universal spring which is looped under all the other springs and aids them in withdrawing the punches from the tape.

10. The feed wheel, together with its shaft and operating ratchet, is also mounted on the punch block as shown in Figure 5.

11. When properly assembled in the perforator the punches are located directly above the punch hammer.

12. This hammer is rigidly mounted on the punch hammer shaft, which in turn is directly connected to the armature shaft through an adjustable coupling.

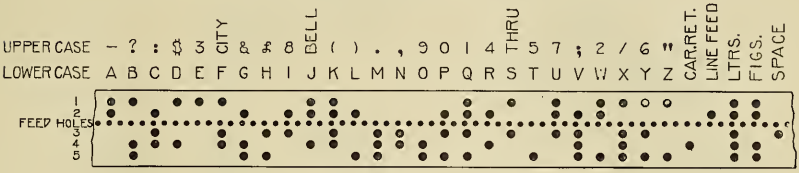
UPPER CASE — ? : $ 3 CITY & £ 8 BELL ( ) . , 9 0 1 4 THRU 5 7 ; 2 / 6 " CAR.RET. LINE FEED LTRS. FIGS. SPACE
LOWER CASE A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
FEED HOLES 1 2 3 4 5

Fig. 4

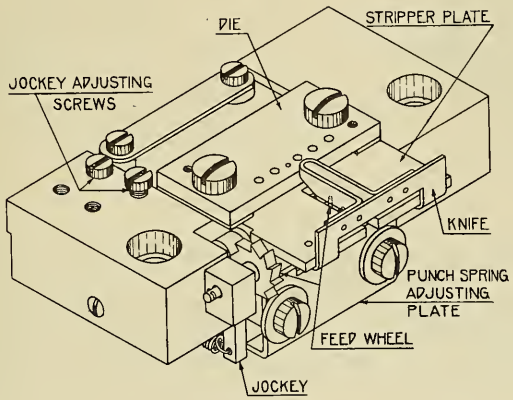


Fig. 5

13. When the operating magnet is energized the shaft is rotated, thus raising the face of the punch hammer so that it engages the feed hole punch and the selecting fingers which have been moved forward by the selecting bars, and forces them upward. This drives the punches through the paper tape.

14. When the magnet is de-energized the armature shaft is returned to its normal position by means of a spring. As soon as the return motion starts, the punches are withdrawn from the tape by means of their springs and the feed pawl, which is mounted on the punch hammer, engages the feed ratchet and steps the feed shaft ahead one tooth on the ratchet. This feeds the tape forward the distance between two consecutive feed holes (1/10 inch).

15. The exact position of the tape with respect to the punches is maintained by means of a jockey roller which engages the teeth of the feed ratchet.

16. The operation of the operating, or punch, magnet is brought about by means of the operating contact. This is located on the right hand side of the perforator. It is closed by the contact bar whenever any key is depressed.

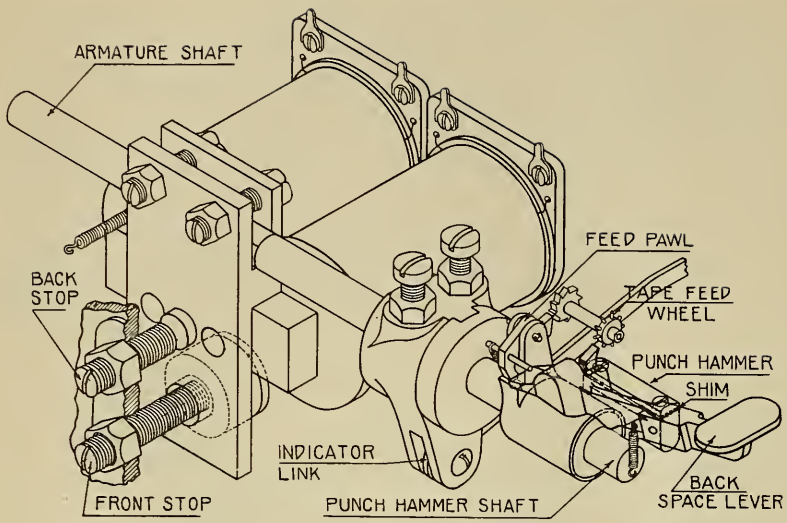


Fig. 6

17. To make it possible to correct conscious errors made by the operator a means is provided for moving the tape back one feed hole at a time and perforating, in place of the wrong character, the LTRS character. Since this character merely causes the printer to shift from the upper to the lower case, if the wrong character were a letter it has no effect whatever on the message being printed, and the operator may go right on with the message after the error has been rubbed out in this manner. If, however, the wrong character were a figure or an upper case character of any kind, the operator must, after rubbing out the wrong character, depress the FIGS key before proceeding to perforate the message again.

18. The back space lever is shown in Figure 6. When it is depressed the feed pawl is pushed away from its ratchet and the back space pawl engages a pin on the feed wheel and pushes this wheel back against the tension of its jockey a distance equal to one feed hole. The jockey locates the tape correctly so that after depressing the back space lever the character previously perforated is again accurately located under the punches.

19. In order that the operator may be enabled to make "lines of the proper length" at the receiving terminal, an indicator is provided on the perforator.

20. This is a pawl and ratchet mechanism as shown in Figure 7. The rocker is connected to the indicator link (Fig. 6) by means of a spring. Every time a character is perforated the actuating pawl is operated so as to cause the ratchet wheel to rotate a short distance. This causes the cord to be wound up on the drum and move the pointer which is fastened to the cord along the scale on the face of the indicator.

21. When sixty-five characters have been perforated a cam on the ratchet wheel closes the lamp contact springs, thus lighting a small lamp located on the left hand side of the keyboard. This lamp indicates to the operator that only seven more characters may be perforated before the LINE FEED and CAR RET keys must be operated.

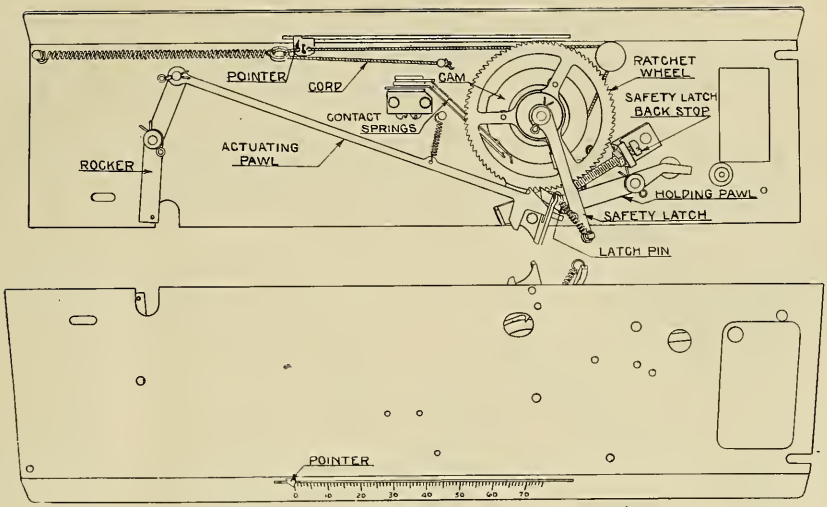


Fig. 7

22. Whenever the CAR RET key is depressed it operates the indicator return lever, which engages the holding pawl on the indicator and pushes it away from the ratchet wheel. The cord immediately unwinds and the pointer is returned to zero.

23. Since the CAR RET key may not be depressed long enough to permit the ratchet and drum to complete its rotation back to the zero point, the holding pawl is provided with a safety latch, which engages the holding pawl, and holds it away from the ratchet wheel until the indicator has returned to zero, when a stop on the ratchet wheel strikes the safety latch and releases the holding pawl.

24. The electrical circuits of the perforator are shown in Figure 8.

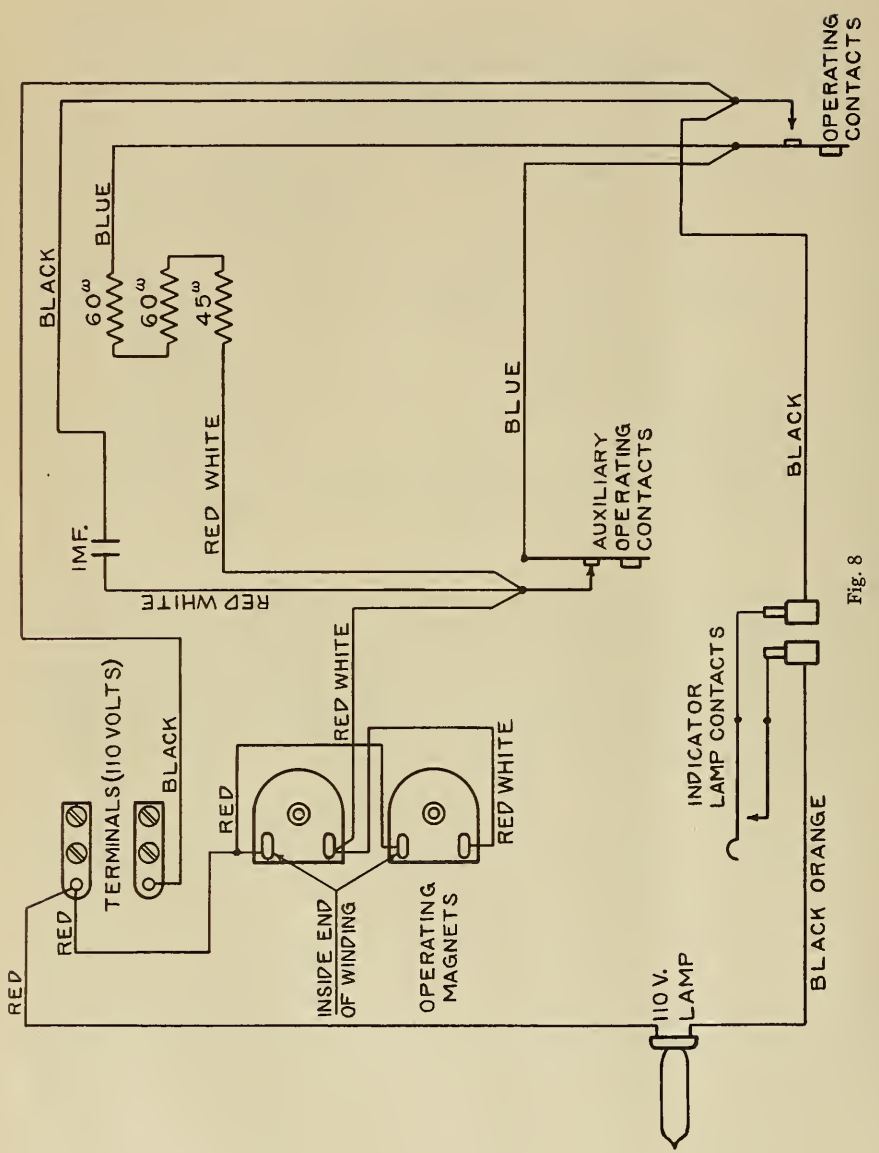
OPERATING CONTACTS
BLACK
BLUE
60Ω
60Ω
45Ω
IMF.
RED WHITE
BLUE
AUXILIARY OPERATING CONTACTS
BLACK
RED WHITE
TERMINALS (110 VOLTS)
BLACK
RED
RED WHITE
RED WHITE
INDICATOR LAMP CONTACTS
RED
INSIDE END OF WINDING
OPERATING MAGNETS
110 V. LAMP
BLACK ORANGE

Fig. 8

## ADJUSTMENTS

1. **General.** Before adjusting, the apparatus shall be thoroughly cleaned, examined for mechanical or electrical defects, and a thin film of oil applied to all bearing surfaces.

2. **Comb.** Push the front comb down, and secure it with its mounting screws as low as the screws permit.

3. **Key Lever Springs.** To adjust the key lever springs depress all selecting and contact bars, and make the tension of the key lever springs such that the key will not move when a ten gram weight is applied to the keys, but will move when a fifteen gram weight is used. The selecting and contact bars may be depressed by holding down the LTRS and M, or the R and Y keys. Use tool No. 165 in making this adjustment.

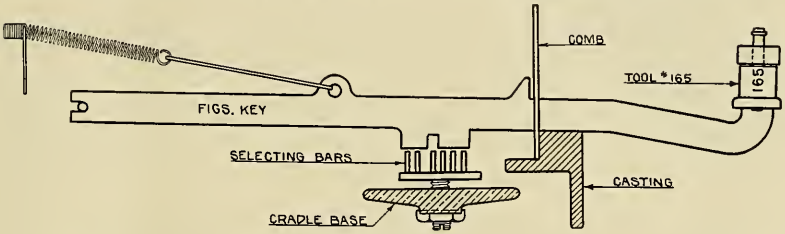


Fig. 9

4. **Selecting Bar Upper Stop.** Adjust the selecting bar upper stop so that the rear, or number 1, bar just clears the selecting projections of the key levers. This stop is located above the left hand end of the selecting bars.

5. **Punch Hammer and Armature Shafts.** See that the punch block is mounted on the perforator base so that the punch hammer shaft and armature shaft are in line with each other.

6. **Selecting Bar Unit Position.** Set the selecting bar unit by means of the screws which hold the cradle base in place so that the punch block connecting levers are vertical and so that the character projections on the key levers will properly select their combinations.

7. **Selecting Bar Lower Stop.** Adjust the selecting bar lower stop so that there is .015 inch clearance between it and the selecting bars when any of the key levers are depressed until they stop on the perforator base casting (Fig. 10).

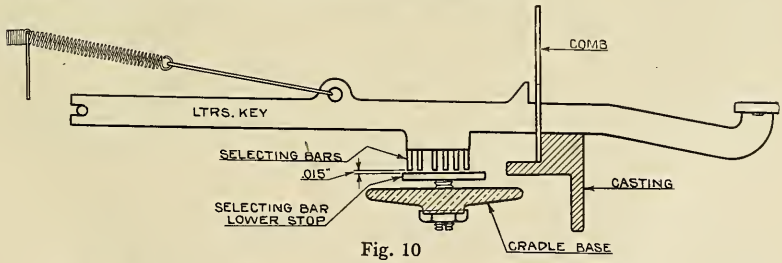


Fig. 10

8. **Selecting Bar Springs.** The selecting bar springs shall have a tension of 40 to 45 grams when stretched to an overall length of 1 5/8 inches. This adjustment shall be made before the springs are assembled on the bars.

9. **Punch Magnet Contacts.** Adjust the punch magnet contacts so they will just close when the selecting bar is 1/16 inch from the end of its stroke.

10. **Punch Block Stripper Plate.** Take the die plate off the punch block and clamp the stripper plate down firmly. See that punches move freely in the stripper.

11. **Punches.** Set the punches .005 inch below the top surface of the stripper plate. This is accomplished by shifting the adjustable angle plate on the punch head.

12. **Assembling of Punches and Die.** Replace the die plate, tap gently so it will find its proper position with respect to the punches and then screw plate down firmly. Be sure that the punches move freely, enter the die plate properly and that their springs have enough tension to pull them down.

13. **Punch Block Angle Plate.** See that there is clearance between the outer end of the punch springs and the vertical adjusting angle plate (Fig. 5).

14. **Selecting Finger Guide.** Adjust the selecting finger guide (Fig. 3) so as to line up the selecting fingers centrally under the punches when the selecting fingers are brought forward. The selecting fingers must work perfectly free in the slots.

15. **Feed Wheel.** Locate the feed wheel, by adjusting the jockey roller so that the tape will be punched on .100 inch centers. The jockey roller adjustment is controlled by two small screws at the far side of the die plate (Fig. 5). Test the tape by using tool No. 161, as shown in Figure 11.

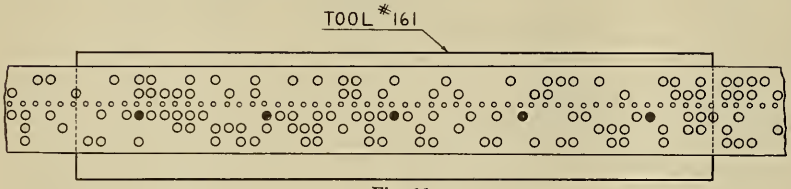


Fig. 11

16. **Jockey Roll Holder Spring.** The tension of the spring holding the jockey roller against the ratchet wheel shall be sufficient to insure the feeding of the tape the full distance of 1/10 inch after the tooth of the ratchet has moved just beyond the center of the roller.

17. **Back Space Key.** Adjust the back space key so that it has just sufficient movement to bring the tooth of the ratchet wheel beyond the centre of the jockey roller allowing the roller to complete the movement of the ratchet.

18. **Punch Magnet Front Stop.** The rubber bumper which acts as the front stop for the punch magnet armature shall be adjusted to eliminate noise and still not prevent the armature from stopping on the magnet cores.

19. **Shaft Coupling.** Set the punches up until they just perforate clean holes in the tape when the "letters" key is depressed. The punches when in their normal position must be slightly lower than the stripper plate and when raised shall be just high enough to cut clean holes and leave no "shutters" on the tape. The stroke of the punches is adjusted "up" by screwing down on the inside coupling screw, and adjusted "down" by screwing down on the outside coupling screw.

20. **Armature Back Stop.** The armature back stop screw shall be adjusted so that the armature will operate the feed wheel, through its pawl, sufficiently to move the feed wheel ratchet tooth just beyond the centre of the jockey roller, allowing the tension of the roller to complete the stepping of the feed wheel.

21. **Indicator Safety Latch Back Stop.** Adjust the safety latch back stop so that with the point of the holding pawl resting in the third notch of the wheel there will be a clearance of .015 inch between the pawl and the face of the tooth. This should allow the latch pin on the holding pawl to just clear the nose of the safety latch when the retaining

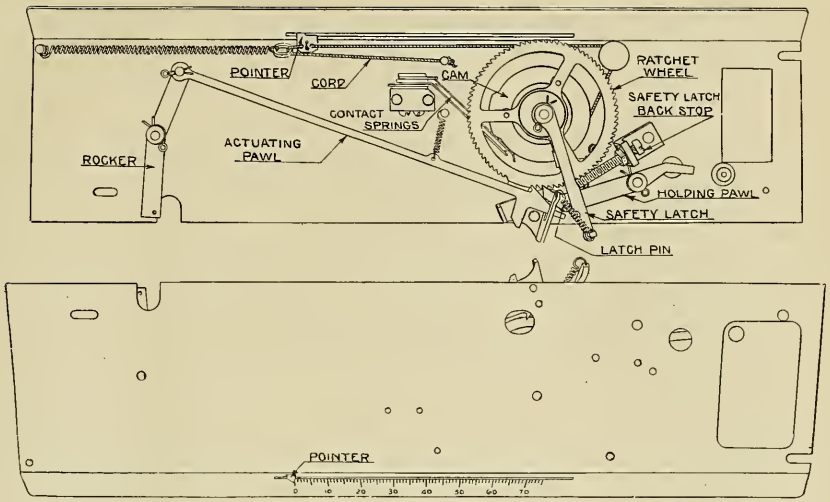


Fig. 7

pawl is operated, to allow the pointer to return to its normal position. With the retaining pawl in the third notch of the wheel, the pointer should be on zero of the indicating scale.

22. **Indicator Cord.** Saturate the indicator cord with a superior quality of machine oil.

23. **Lamp Contact Springs.** The contact springs for the lamp shall be adjusted so as to light the lamp when the pointer indicates 65 on the scale.

24. **Indicator Position.** Mount the indicator on the perforator and shift laterally until its actuating pawl clears the tooth of the ratchet wheel by .015 inch on return stroke.

25. **Indicator Spring.** The adjustment of the spring of the indicator must be such that the pointer will return to zero position when it has been stepped to indicate one character and then released.

26. **Punch Magnet Retractile Spring.** The punch magnet armature retractile spring shall have sufficient tension to operate the tape feed wheel and the indicator when the armature is slowly returned by hand.

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 4-A

PERFORATOR 2-A

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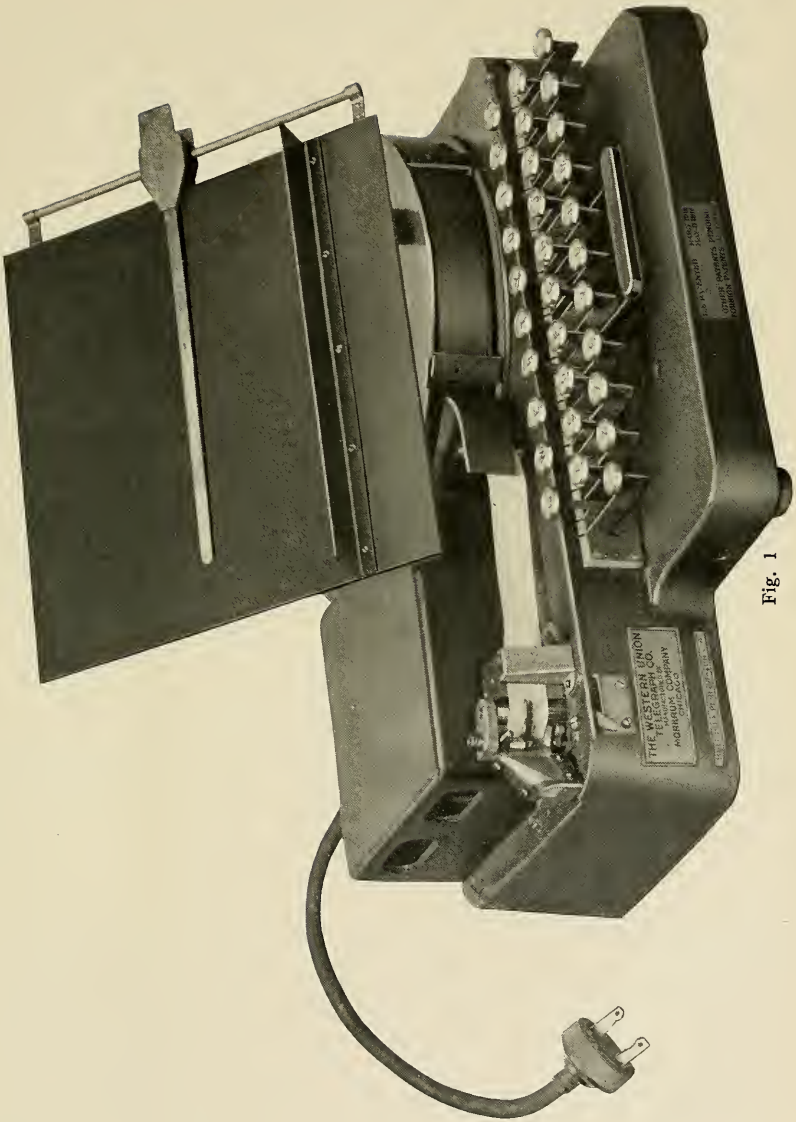
THE WESTERN UNION
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AUTOMATIC
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WEST VA.

Fig. 1

## MULTIPLEX PERFORATOR 2-A

1. Keyboard Perforator 2-A is a device controlled by a typewriter keyboard for perforating holes in a paper tape to form the characters representing in the Multiplex alphabet the message to be transmitted.

2. Its essential parts are:

(a) A punch block containing a die plate and six punches comprising one for punching the small feed holes, and five for punching the selecting holes that determine the character to be transmitted. The paper tape passes through this punch block.

(b) A magnetically operated punch hammer which forces the punches through the tape.

(c) A system of five selecting levers that may be withdrawn from their position between the punch hammer and the punches so as to determine which of the five selecting holes shall be perforated.

(d) A typewriter keyboard by means of which the selecting levers and punch magnet are controlled.

(e) A device for feeding the punched tape.

3. The keyboard is arranged as shown in Figure 2. There are thirty-one keys and a space bar. Twenty-six of the keys have the letters of the alphabet on the lower case; figures or punctuation marks, etc., on the upper case. One key, marked FIGS, represents the signal which causes the printer to shift to the upper case. After it is depressed all the combinations following represent upper case characters until the key marked LTRS is depressed. This key represents the signal which restores the printer to the lower case. the key marked CAR RET represents the signal which causes the printer carriage to return to such a position that the printing will be started at the left hand margin of the paper, and the one marked LINE FEED represents the signal that causes the printer to feed the paper up to a new line. The space bar represents the signal that causes the printer to make the space between words. One key is blank and perforates only feed holes.

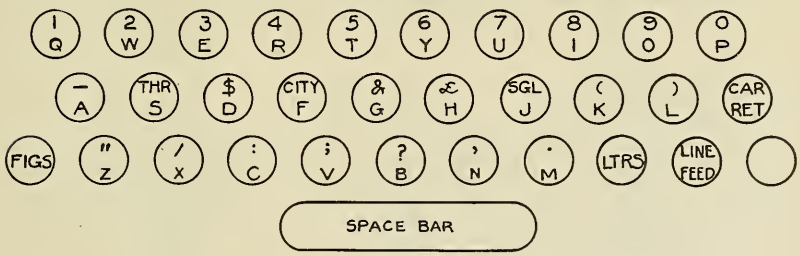


Fig. 2

4. All the key levers are pivoted on a long rod supported beneath the perforator frame. Each key lever is provided with a curved wire spring which restores the lever to its normal position when released by the operator. A combination of teeth known as a comb, projecting downward, is fastened to each key lever. The arrangement of these teeth determines the combination of perforations to be made in the tape, which in turn represent the different signals or characters. Thus each key is capable of performing the selecting operations required to produce the proper perforations in the tape.

5. Directly beneath the combs are six bars, or loops, extending transversely to the key levers. When a key is depressed the comb attached to that key lever operates certain of these loops. Figure 3 shows this arrangement. The foremost loop is the power loop which closes the contacts of the punch magnet circuit, causing the punch magnet to

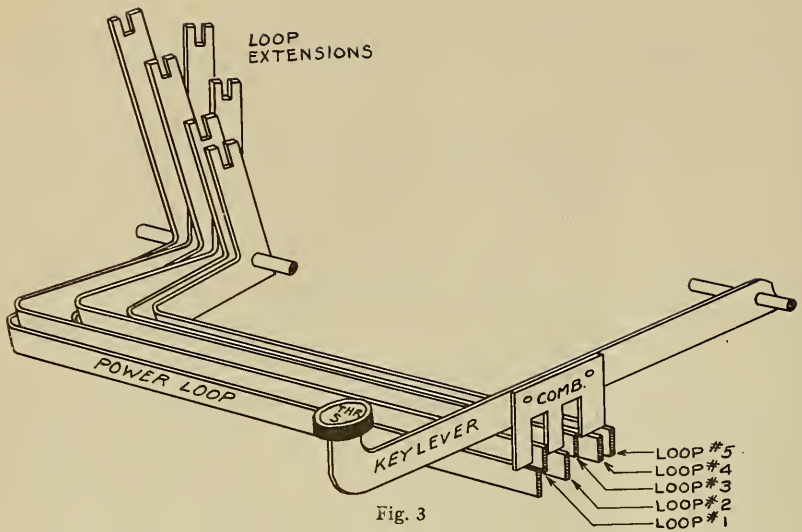
LOOP EXTENSIONS
POWER LOOP
COMB
KEY LEVER
LOOP #5
LOOP #4
LOOP #3
LOOP #2
LOOP #1

Fig. 3

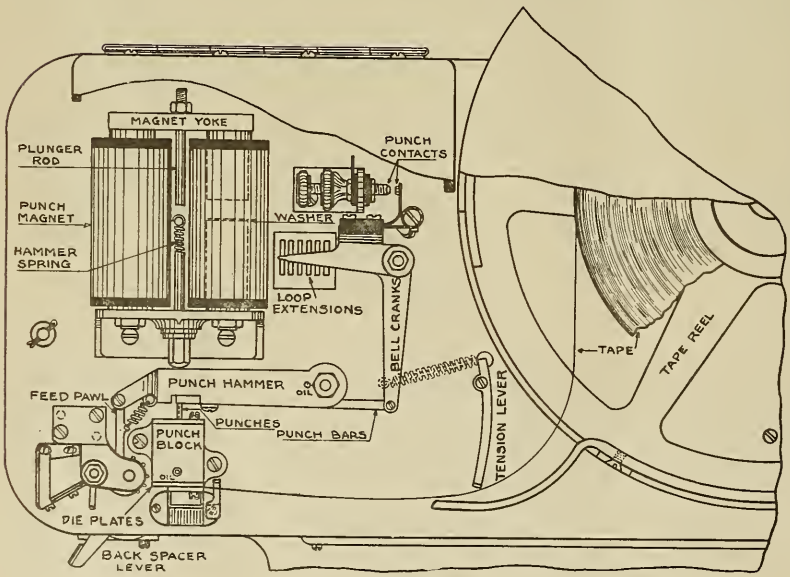
MAGNET YOKE
PLUNGER ROD
PUNCH MAGNET
HAMMER SPRING
PUNCH CONTACTS
WASHER
LOOP EXTENSIONS
BELL CRANKS
TAPE
TAPE REEL
PUNCH HAMMER
FEED PAWL
PUNCHES
PUNCH BARS
PUNCH BLOCK
TENSION LEVER
DIE PLATES
BACK SPACER LEVER

Fig. 4

operate. The power loop is operated whenever any key is depressed. The six loops have extensions which project through the base of the perforator and engage bell cranks which are pivoted about a common vertical post. Five of these bell cranks in turn engage punch bars which are interposed between the punch hammer and the punches. The depression of any loop withdraws the corresponding punch bar from in front of its punch so that when the punch hammer is operated by the magnet the corresponding hole is not punched in the tape. Thus if loops 2, 4 and 5 are depressed by the key comb the space assigned to holes 2, 4 and 5 on the tape will remain intact and numbers 1 and 3 will be perforated and we will have the signal for the letter "S."

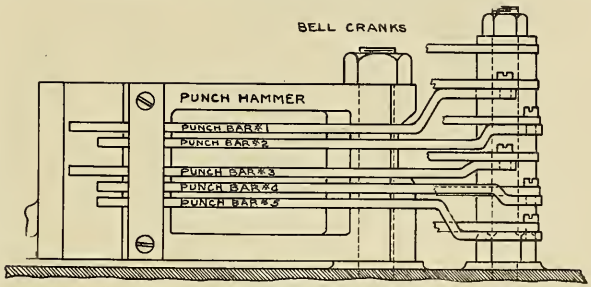


Fig. 5

6. The punch block contains six punches, five of these corresponding to the five units of the code, and the sixth being used to perforate feed holes in the tape. This hole is the third from the top of the tape and is somewhat smaller than and slightly in advance of the other. The five punches corresponding to the units of the code are on a line at right angles to the length of the tape. It will be noticed that the feed hole punch is longer as well as smaller than the other five punches. Whenever the punch hammer is operated it strikes this longer punch thus perforating a feed hole in the tape.

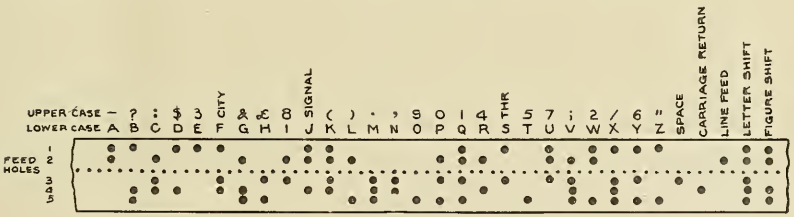
UPPER CASE – ? : $ 3 CITY & & 8 SIGNAL ( ) . , 9 0 1 4 THR 5 7 ; 2 / 6 " SPACE CARRIAGE RETURN LINE FEED LETTER SHIFT FIGURE SHIFT
LOWER CASE A B C D E F G H I J K L M N O P Q R S T U V W X Y Z
FEED HOLES 1 2 3 4 5

Fig. 6

7. Spaced at equal intervals around the feed roll are twelve projecting feed pins, which mesh with the small feed hole punches in the tape. A pressure arm is used to hold the perforated tape firmly against the feed roll so that the teeth of the feed roll engage the feed holes in the tape. Beneath the feed roll but on the same shaft is a feed ratchet with twelve teeth.

8. A feed pawl is pivoted to the end of the punch hammer and is held against the ratchet by means of a spring. When the punch hammer is moved forward by the action of the punch magnet, the feed pawl also moves forward and engages a tooth of the feed ratchet. When the punch magnet is de-energized, the hammer spring pulls back the punch hammer and the feed pawl in retracting with the punch hammer causes the feed roll to revolve and move the tape forward a distance of one feed hole (1/10 inch).

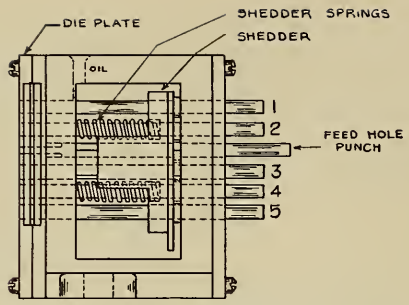


Fig. 7

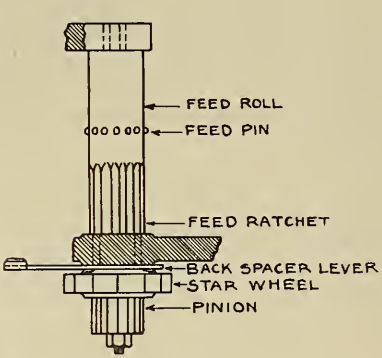


Fig. 8

9. The travel of the tape for each operation of the punch hammer is accurately limited by a twelve toothed star wheel, attached to the lower end of the feed roll shaft, against the teeth of which the roller of an adjustable feed detent is held by means of a strong spring. An eccentric bushing, which is the pivot of this detent, provides a means for adjusting the position of the roller. By varying the position of the eccentric bushing, the distance between successive tape perforations may be increased or decreased until the desired ten feed holes per inch are obtained.

10. The perforator is equipped with a tape tension lever located slightly to the left of the tape reel (Fig. 4). The purpose of this lever is to take the direct pull of unwinding the tape from the feed roll. The tape is placed upon the reel so that in unwinding it will revolve in a counter-clockwise direction. The tape passes in front of the tape tension lever and thus when the feed roll revolves and pulls the tape forward, the pull will be against the tension lever, causing its spring to be extended. As this spring attempts to return the tension lever to its normal position it will unwind the tape from the reel slightly, always leaving it slack. If the tape does not pass in front of the tension lever the feed roll will be forced to pull against the weight of the tape reel in moving the tape forward and the feed holes are apt to be torn or elongated.

11. Provision is made for moving the tape backward to facilitate the correction of errors made in punching the tape. This is accomplished by means of the back spacer lever which is pivoted at the feed roll axis and is equipped with a pawl and spring. When

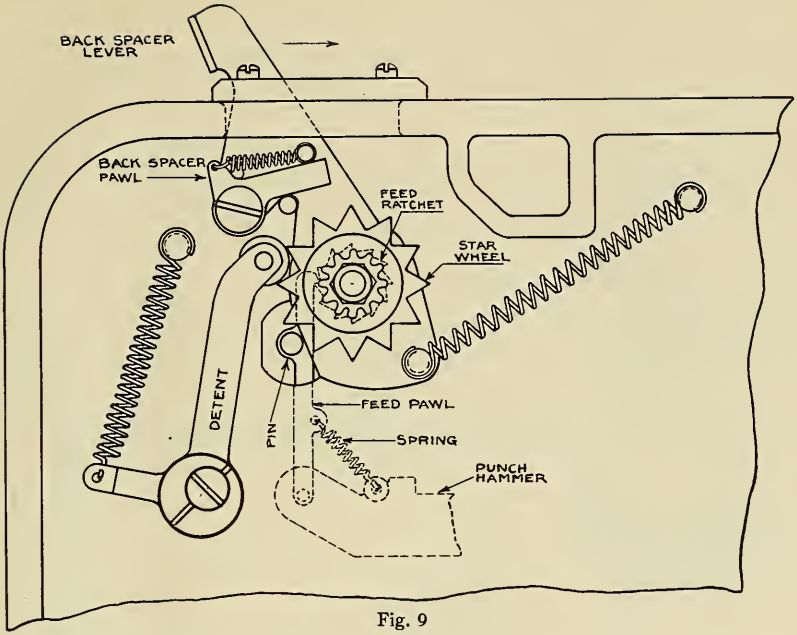


Fig. 9

this lever is first pushed to the right its edge engages a pin projecting from the feed pawl, thus moving the feed pawl out of mesh with the feed ratchet. Further movement of the back spacer lever permits its pawl to engage a tooth on the star wheel and rotate the feed roll shaft backward one space. This places the last prepared line of perforations in front of the punches. The tape is moved back the distance of one feed hole each time the lever is operated.

12. If a wrong word has been perforated it can be rubbed out by operating the back spacer lever successively until the first character to be corrected is in front of the punches. (The back spacer lever should not be held operated.) Then operate the LTRS key as many times as there are characters to be corrected. The combination for LTRS being five marking impulses, the tape will be perforated by all the punches in the punch block.

13. When the LTRS combination is sent over the line no character will be printed by the distant printer. If this printer were printing in its "letters" position when the operator perforated the wrong word, the correct word may be perforated immediately following the "rubout." If, however, the printer was printing in its "figures," position when the rubout was made, the FIGS key of the perforator must be depressed before perforating the correct characters in order to restore the distant printer to its "figures" position. In all cases no correction of the error will appear on the received printed copy.

14. When the number of characters perforated reaches sixty-five, seven less than the allowable number on a line in the printer, a small lamp under the keyboard is lighted. This lamp is protected against breakage by a movable, perforated sheet metal guard and is lighted by the closing of a mechanically operated contact. The contact is closed by the action of a larger gear, known as the indicator gear (Fig. 9). This gear meshes,

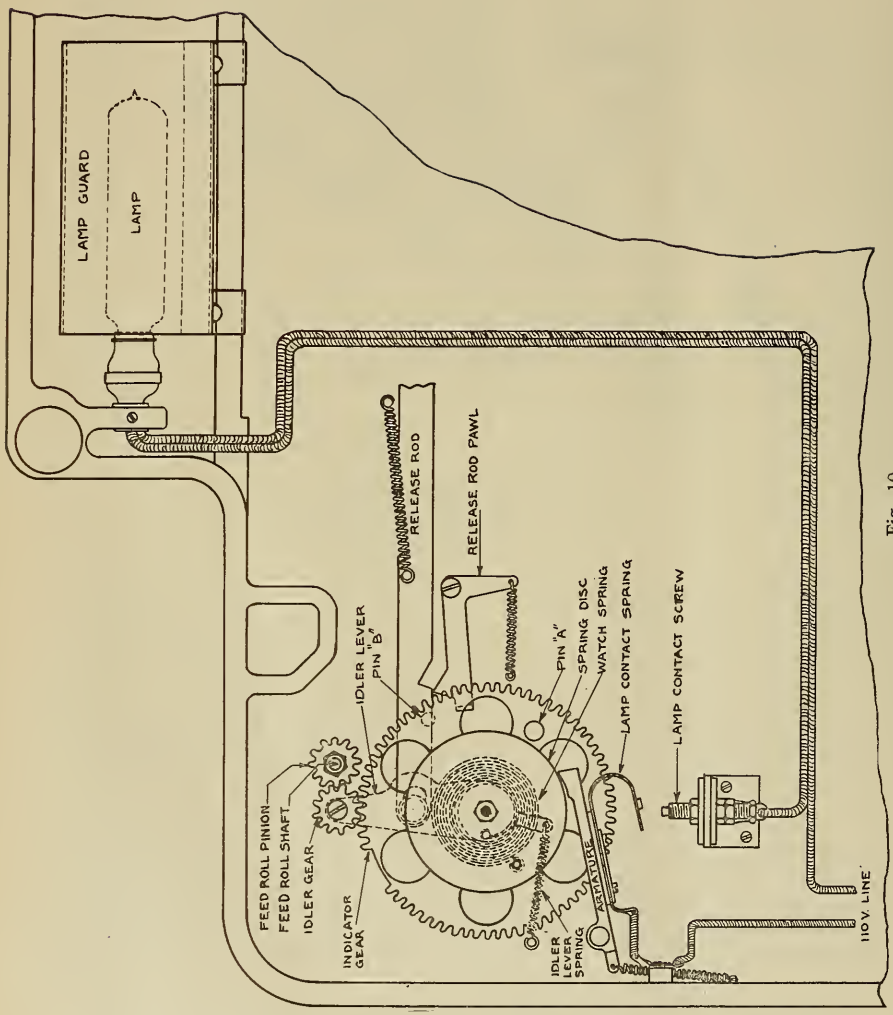
LAMP GUARD
LAMP
RELEASE ROD
RELEASE ROD PAWL
IDLER LEVER PIN "B"
PIN "A"
SPRING DISC
WATCH SPRING
LAMP CONTACT SPRING
LAMP CONTACT SCREW
FEED ROLL PINION
FEED ROLL SHAFT
IDLER GEAR
INDICATOR GEAR
IDLER LEVER SPRING
ARMATURE
110 V. LINE

Fig. 10

through an idler gear mounted on a lever, with the twelve toothed pinion on the feed roll shaft. Thus whenever the feed roll moves the tape forward one space the indicator rear also advances one tooth.

**15.** Mounted on the indicator gear is a pin, A, which when the gear has moved sixty-five teeth from its initial position strikes an armature and presses it against the lamp and signal to the operator, indicating that only seven more characters can be perforated on the line.

**16.** The revolving of the indicator gear winds up a watch spring, one end of which is attached to the gear and the other end fastened to the spring disc which is stationary. When the operator depresses the "CAR RET" key, the key lever strikes a bell crank which moves the release rod to the left. This throws the idler gear out of mesh with the feed roll pinion and the indicator gear is quickly returned to its initial position by the watch spring, and the lamp contacts are opened.

**17.** Since the CAR RET key may not be depressed long enough to allow the gear to get all the way back to its initial position, a notch is cut in the release rod. When this rod is moved to the left, a spring actuated pawl known as the release rod pawl moves into the notch, holding the rod in such a position that the idler gear is held out of mesh. When the indicator gear has almost returned to its initial position, a projecting pin B strikes the release rod pawl and knocks it out of the notch in the rod. This action allows the indicator idler gear to again mesh with the feed roll pinion.

## ADJUSTMENTS

1. **General.** Before adjusting the perforator, this unit shall be thoroughly cleaned and examined for mechanical or electrical defects. A thin film of oil shall be applied to all bearing surfaces.

2. **Key Lever Springs.** To test the tension of the key lever springs, hold the blank key depressed. This will hold all the loops operated and clear of the combs on the other key levers. It should require 1/4 to 3/4 ounce, applied on any key cap, to depress that key. If the force required to depress any key is not within these limits, the key lever spring shall be removed and bent to adjust the tension. If the force required to depress the key is too small, the spring must be spread, and vice versa (Fig. 11). Make sure that the key levers move freely at the pivot and in the guides without sticking. A simple method of adjusting the tension of a number of these springs to approximately the same value is to set their spread at 2 inches. Figure 12 shows how this should be measured. This method affords a means of quickly adjusting the key lever springs of a perforator to give approximately the desired action.

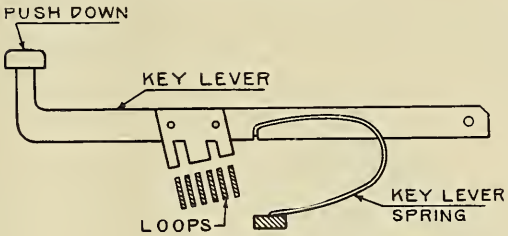

Fig. 11

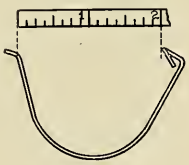
Fig. 12

3. As the CAR RET key strikes the release rod bell crank after it has been depressed a short distance, its tension shall be measured just as it starts to move and before it strikes the bell crank. In this connection it is well to remove the release rod spring and determine if the release rod moves freely, for if it does not the CAR RET key will require an abnormal pressure to depress it fully.

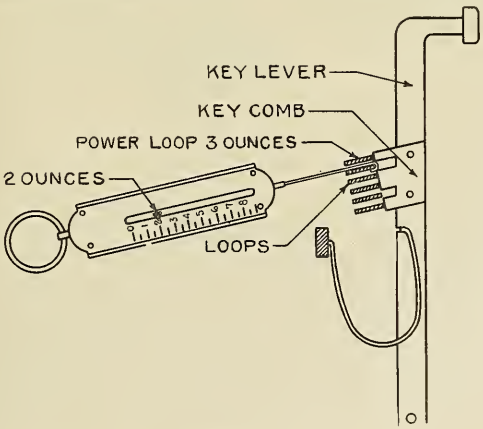

Fig. 13

4. In order to test the blank keys the CAR RET and LINE FEED keys must be depressed simultaneously.

5. **Loop Springs.** It is important that the loop springs have a proper tension, for if they are too strong, the touch of the keys will be heavy, and if they are too weak, the loops will not return promptly after being released by the key lever comb. Thus a punch bar may lag and so cause the loss of a unit pulse in the next character perforated. Stand the perforator on the rear edge and hook the spring balance on the edge of the loop beneath the key combs. A tension of two ounces with the spring balance in a horizontal position should be sufficient to start movement of the loop. If the tension required to move the loops is more or less than two ounces, the springs shall be removed and bent until they give the required tension.

6. **Punch Magnet Contacts.** Loosen the lock nut on the contact screw and advance the contact screw until holes are perforated in the tape when the blank key is very slowly depressed. Now back off the contact screw one-half turn and tighten the lock nut while the screw is held in this position. If the contact screw is not turned in far enough, the perforator is apt to skip; that is, the punch magnet may fail to operate because the contacts barely close when a key is depressed. If the contact screw is set too close, the touch of the perforator will be heavy, due to early operation of the punch magnet. The punch magnet contacts shall be kept clean and smooth. They shall be polished at frequent intervals with a carborundum stone and when badly worn or burned, they shall be replaced.

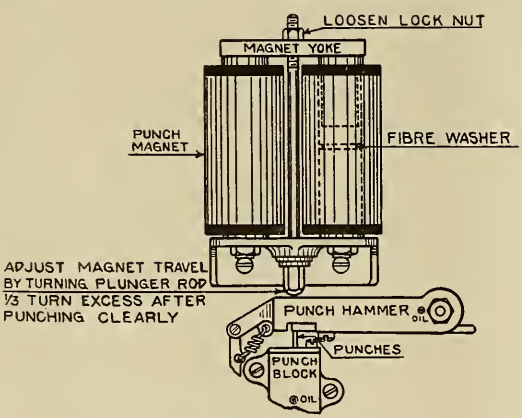


Fig. 14

7. **Plunger Yoke Travel.** The travel of the punch magnet plunger yoke determines how far the punches will be driven through the paper and into the die plate. The travel of the plunger yoke shall be just sufficient so that the punch hammer will drive all the punches through the paper and produce clear, clean cut perforations. To adjust, loosen the lock nut on the punch magnet plunger rod and shorten the effective length of this rod by turning it with a wrench until the holes are not perforated in the tape when the LTRS key is struck. Then lengthen the plunger rod until the holes are perforated clearly when the LTRS key is struck. Turn the rod one-third of a turn further to insure a sufficient travel of the punch hammer. With this adjustment the tape will be punched cleanly and the magnet will have sufficient strength to perform its work. If the stroke of the magnet is too short the perforations in the tape will not be clean. If the stroke is too long the air gap between the yoke of the magnet and the magnet core will be so

great that the pull of the magnet will be weakened so that the punch hammer will fail to drive all the punches through the tape.

8. **Plungers.** The plungers should move freely within the solenoids. In order to prevent them from sticking to the cores of the solenoids, a german silver or a fibre washer is placed in each solenoid.

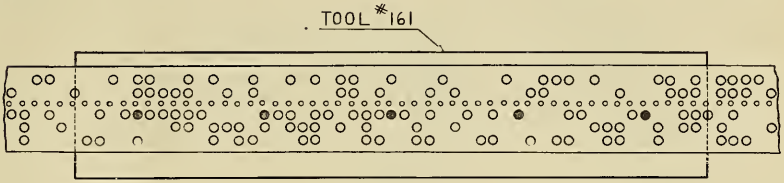


Fig. 15

9. **Punch Hammer.** The punch hammer should move freely on its bearing post when the heavy spring is detached. The tension of the punch hammer spring should be such that it returns the hammer and advances the feed roll smartly. If it is sluggish in returning, the spring is too weak, or, more likely, the plunger rod, punch hammer or feed roll may be sticking and not moving freely. This defect would cause the characters to be punched too close together. The plunger rod washers should always be thick enough so that the face of the feed pawl comes to rest slightly forward from the face of the feed roll tooth it has just engaged.

10. **Method of Starting Tape in Perforator.** Tear off the tape squarely, run it over the tape guide, thread through the die plates of punch block and let it project about an inch toward the feed roll. Raise the tape tension fork from the roll and slip the tape into place. Hold the tape firmly against the feed roll by putting a little pressure on the handle and operate the blank key until the tape feeds itself properly.

11. **Tension Fork Spring.** The spring which presses the tension fork against the feed roll should be sufficient to feed the tape evenly. If this tension is too weak the tape will not grip the feed roll and uneven spacing will occur. Too heavy a tension may mutilate the feed holes or make it difficult for the feed pawl to turn the feed roll. To adjust the tension fork spring, remove tension shaft and unwind or wind up the spring around it to obtain the desired tension.

12. **Tape Feed.** To accurately adjust the tape feed, the detent which is held against the twelve toothed star wheel attached to the lower end of the feed roll shaft is made adjustable. By loosening the locking screw and turning the eccentric bushing the location of the detent roller is varied, which in turn changes the distance between successive tape perforations. The signal lamp indicator gear assembly should be removed and left off until the correct gauge of the tape perforations is obtained. There should be exactly ten feed holes per linear inch of tape and this shall be checked by means of the tape gauge multiplex tool No. 161 as shown in Figure 15.

13. **Indicator Spring.** The watch spring of the indicator is regulated by holding the plate to which the watch spring is attached and loosening the lock nut. The spring shall then be adjusted by winding it tight and then unwinding it one turn, after which the lock nut shall be tightened. This should be done with the gear in its final position as shown in Figure 16. If the spring is wound too tightly it will bind and the gear will not turn to its initial position when the carriage return key is depressed. If the spring is not wound tightly enough the gear will be slow in returning and perhaps will not have force enough to knock the pawl out of the notch in the release rod. To insert an indicator watch spring, remove the spring disc and the large gear and attach the inner end of the spring to the spring post of the gear and the outer end to the spring post on the disc. Wind up the spring by holding the gear and turning the disc, then place the two in position together and secure by means of the locknut.

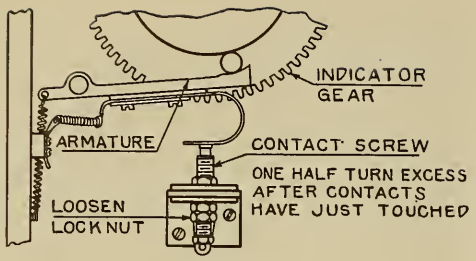


Fig. 16

14. **Lamp Contacts.** The indicator lamp should light on the sixty-fifth character perforated. To test this, strike the carriage return key in order to make sure that the indicator gear is in its initial position, then depress a key sixty-five times and adjust the lamp screw until it just makes contact against the contact spring and lights the lamp. Turn the screw in one-half turn excess and tighten lock nut (Fig. 16). If the screw is turned in too far it may press the spring armature against the pin on the indicator gear too strongly and prevent the gear from returning quickly when the carriage return key is struck.

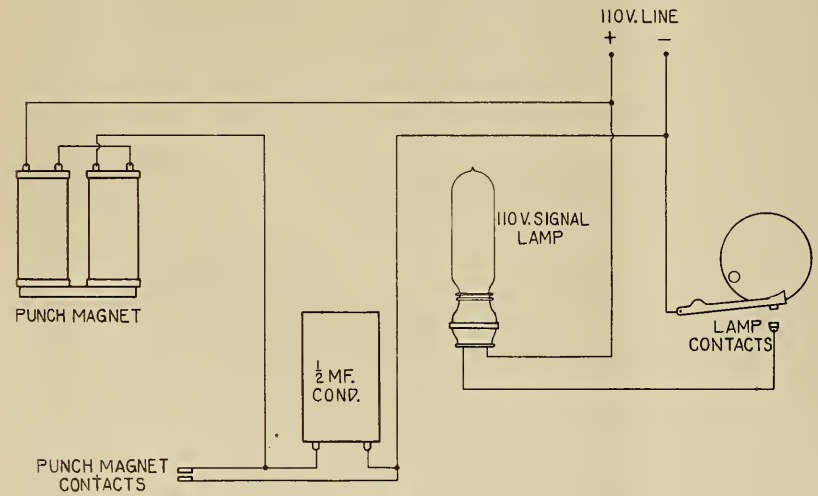


Fig. 17

15. The electrical circuits of the perforator are shown in Figure 17.

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 5

PRINTER 1-A

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**SPECIFICATIONS INCLUDED:** None.

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WESTERN UNION
TELEGRAM
THE WESTERN UNION TELEGRAPH CO.
Western Electric
COMPANY
MULTIPLEX PRINTER 14A

Fig. 1

## MULTIPLEX PRINTER 1-A

1. In the theoretical description of a possible multiplex system given in Section 1, the printing of the message was done by an ordinary typewriter, to which had been attached a selecting unit and other auxiliary mechanism.

2. In actual service the printing is done by apparatus built specially for this kind of work. This apparatus is known as the printer.

3. This section deals with the 1-A printer, which is one of several types used in connection with the multiplex telegraph system.

4. In all printers it is essential to provide some means for causing the received impulses of the code to select or reject certain corresponding mechanical elements in the printer and to hold or store each selected mechanical element until all other elements have been either selected or rejected, and then at a definite moment cause this selected mechanism to operate and perform some predetermined function.

5. In the printer under consideration the selecting mechanism determines the stopping point of a rotating typewheel, or closes any one of a set of contacts, for performing functions other than printing. It consists essentially of five horizontal discs, one for each unit of the multiplex code, each one having thirty-four notches, or slots, in its periphery, so mounted as to have a limited motion about a hollow drum or shaft.

6. The motion of the discs is controlled by five selecting magnets, one for each unit of the code. These in turn are operated by the selecting relays which receive the line impulses from the distributor, so that for every selecting relay operated, one disc is rotated as far as its limiting stop permits. Figure 2 shows schematically the discs and some of the associated parts in perspective.

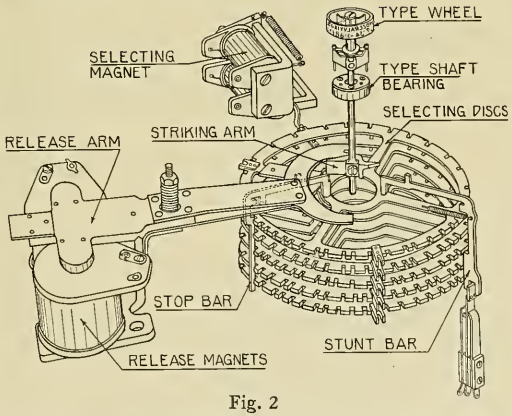



Fig. 2

7. The notches in the discs are so located with respect to each other that for every setting of the discs, whether they are all against their back stops, or whether one or more are moved against their forward limiting stops, five slots or notches line up vertically at one or, in some cases, two positions around the periphery of the discs.

8. Directly above all but one of these positions a small right angled lever is placed. These levers are pivoted at the apex of the angle and held so that the vertical arm rests close to the slotted discs. They are held clear of the discs, normally, by two semicircular extensions of the armatures of two magnets, called release magnets, which rest on the horizontal arm of the right angled levers. Each of these levers represents a letter, character, or function that the printer is designed to perform. Since there is no charac-

ter or function selected when all the discs are resting against their back stops the lever corresponding to this position is omitted. The levers that represent letters or characters are called stop bars, those representing functions, stunt bars.

9. Figure 3 shows the location of the bars representing the different letters and functions; Figure 4 the actual construction of the selecting mechanism.

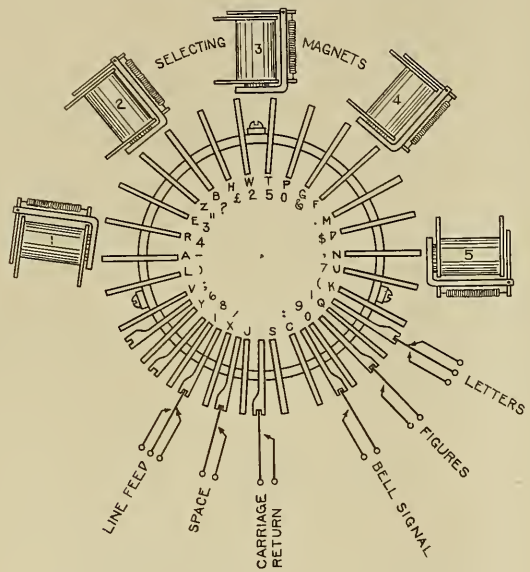



Fig. 3

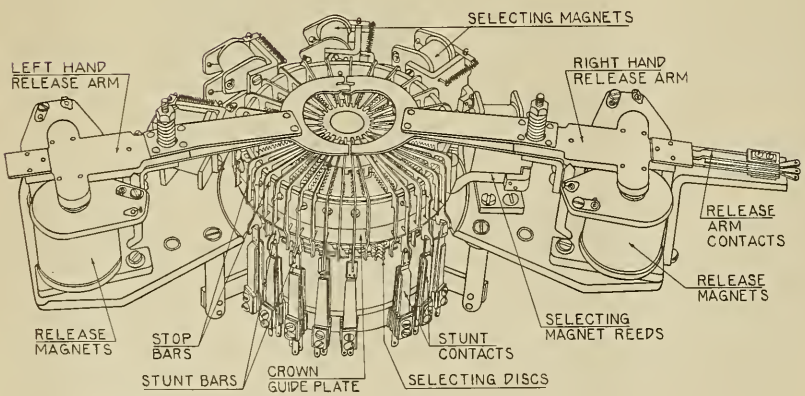



Fig. 4

10. In the center of the drum or hollow shaft about which the slotted discs move is a vertical shaft carrying a light typewheel. This shaft is kept under tension by a spring, wound at required intervals by a small motor. Projecting at right angles from the vertical typewheel shaft is a small arm, called the striking arm, which is so mounted that it just clears the tips of the stop bars.

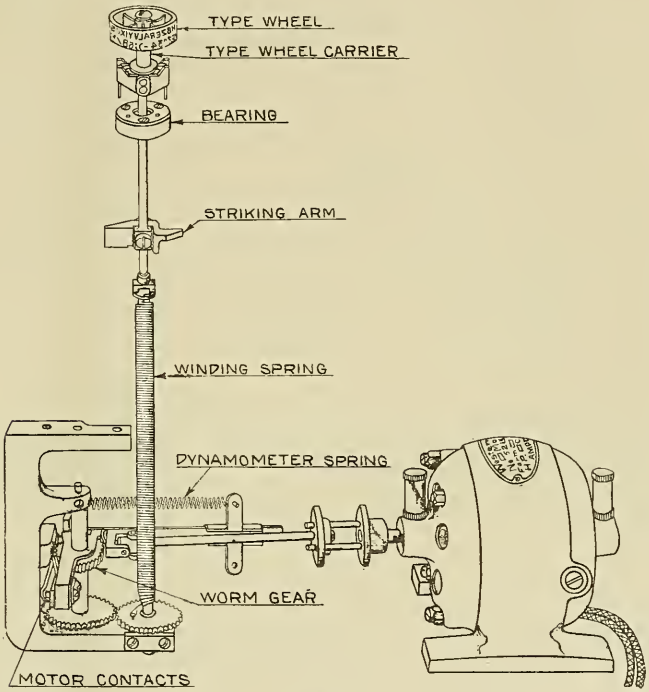



Fig. 5

11. When one or more selecting relays have been actuated by a combination of impulses representing a letter transmitted from the distant station, the corresponding selecting magnets move their discs into the selected position. If the release magnets be now energized, the semicircular extensions of their armatures are raised, thereby allowing the vertical arms of the previously mentioned stop bars to press against the slotted discs. At some point in the periphery of the discs there will be five slots in line which will allow the vertical arm of the stop bar opposite this point to fall in. At the same time the horizontal arm of this bar will rise into the path of the striking arm on the typewheel shaft. Simultaneously with the setting of the stop bar the typewheel shaft is released and under tension of its spring rotates rapidly until its striking arm strikes the selected stop bar to which we have just referred. This stops the typeshaft and consequently the typewheel, and as the arm strikes the stop bar, a circuit through a magnet is completed. This magnet forces the paper against the typewheel and prints the character corresponding to the stop bar selected. The striking arm on the typeshaft is, of course, definitely located with respect to the stop bar and the character to be printed. As the character is printed the carriage is spaced to the left the distance of one character ready for the next operation. If a combination representing a function instead of a letter had

been received by the printer, the performance of the printer would have been similar to that described except that the printing magnet would not have operated. These operations will be described in detail later.

12. As already mentioned the line signals are received by five selecting relays. These, together with auxiliary relays used in the operation of the printer, also most of the resistance units and some of the condensers used in the apparatus, are mounted in a metal box, which for the sake of convenience is connected to the printer mechanism by means of spring clips. Two of the relays used in the relay bank are shown in Figure 6. All of the relays in the bank are of the same general construction, differing only in the number of turns and resistance of the windings and the number and kind of contact springs used.

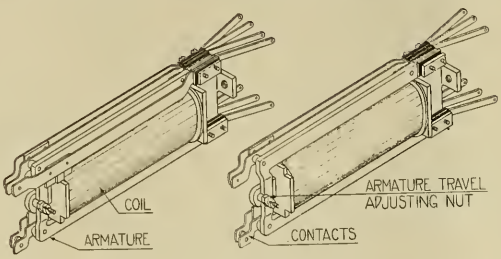



Fig. 6

13. In order that we may gain a clear understanding of the operation of the selecting relays and the auxiliary apparatus in conjunction with the selecting mechanism of the printer which we have already described, let us refer to Figure 7. This is a schematic drawing of the printer and selecting bank circuits connected in the proper manner to the receiving and local rings of the distributor. Let us assume that the heavy line in the 110 volt local supply circuit is connected to the positive and the fine line to the negative source of supply.

14. It will be seen that the first five segments of the receiving ring are electrically connected to five selecting relays; consequently, a marking impulse received on the first receiving segment will operate the first selecting relay. A marking impulse received on the second receiving segment will operate the second selecting relay, and so on for the three remaining selecting relays. It will be noticed that each of these five selecting relays has two tongues, both of which when operated press against their respective contacts. The tongue and its contact on the left of each selecting relay is termed the locking contact, and the tongue and contact on the right of the relay is termed the selecting contact. The necessity for equipping each selecting relay with a locking contact is made manifest when we consider the short marking impulse each selecting relay receives for its operation. The duration of a marking impulse through each selecting relay is governed by the time of transit of the receiving brush over that particular receiving segment to which a selecting relay is connected. When the brushes of the distributor are revolving at the rate of, say, 245 revolutions per minute, the duration of the impulse received by any of the selecting relays is about .006 second. This is much too short a time for the printer to execute any function, hence the selecting relay must be quick in action and must also be capable of holding in reserve or storing up a short marking impulse for the length of time required by the printer to set its selecting discs in preparation for the printing of any selected letter or the performing of a function.

15. Let us see what will take place if the letter "E" is to be received. The combination which represents this letter consists of one marking impulse followed by four spacing impulses. This means that only the first selecting relay of the printer must be energized when the distributor brushes pass over the receiving segments. When the receiving brushes pass over the first receiving segment a circuit is established from the negative battery on the printer relay through the receiving rings, the coil of the first selecting relay,

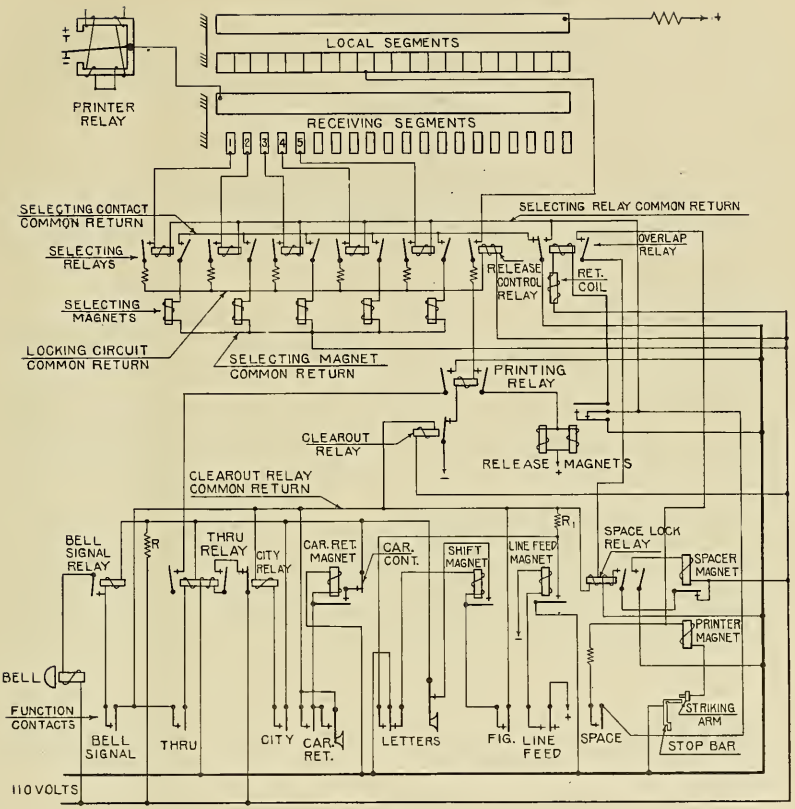



Fig. 7

the selecting relay common return circuit, the right hand release magnet contacts to positive battery. A current therefore flows through the relay and causes it to close its contacts. The closing of the left hand contact "locks" the relay in its operated position by applying to the left hand end of the relay coil a negative battery so that after the brush passes to the next segment, thus cutting off the negative battery from the printer relay contact, the current flow is maintained. The path of this negative battery is through the left hand contact, the locking circuit common return, the coil of the release control relay to negative battery. The flow of current through this circuit also operates the release control relay.

16. As the brushes pass to the second segment the printer relay is reversed in accordance with the signal being received. There can be no current flow through the second selecting relay, for we now have positive battery on the printer relay armature, and we have already seen that the selecting relay common return circuit is also connected to positive battery. The brushes pass on to the remaining three segments in the same manner. So long as the printer relay tongue is in contact with the spacing side of the relay no selecting relays will be operated.

17. Now we return to the first selecting relay which was locked up by the locking circuit in its operating position. The right hand contact is now closed and a circuit is formed from positive battery on the tongue of the left hand contacts of the overlap relay, through the back contact, the selecting contact common return circuit, the right hand contact and tongue of the first selecting relay through the first selecting magnet, the selecting magnet common return to negative battery. This operates the first selecting magnet, thus rotating the first selecting disc as already described.

18. Nothing further can take place in the printer until the distributor brushes have advanced to the position where the local brushes make contact with segment 9 of the local ring. When this point is reached a circuit is established from the positive battery on the solid local ring through the brushes, segment 9, the contacts of the release control relay, the coil of the printing relay, the contacts of the clearout relay to negative battery. This causes the printing relay to be energized, thus attracting its armature and closing its contacts. The closing of the right hand contact locks the relay in its operated position by establishing a circuit from positive battery at the lower coil terminals of the release magnets, through these magnets, the right hand contacts of the printing relay, the coil of this relay, the contacts of the clearout relay to negative battery, as before. From this point on until the letter "E" has been printed the printer operates entirely unassisted by the distributor or any outside source.

19. The flow of current through the circuit last described causes the release magnets to be operated. The operation of these magnets causes the semicircular extensions of their armatures to be lifted from the horizontal arm of the stop and stunt bars, as already described, thus permitting the vertical arm of the stop bar representing the letter "E" to move into the slot prepared for it by the selecting discs.

20. The movement of the release arm also performs two additional duties. The three functions are carried out simultaneously, but for the purpose of description we must, of necessity, describe them in succession.

21. The second function that we shall describe is the operation by the right hand release magnet of a set of contacts to which we already have referred. The path from the selecting relay common return to positive battery is broken, and a new path is established from positive battery on the lower contact through the top contact to the coil of the overlap relay, through its retardation coil and thence to negative battery.

22. The breaking of the selecting relay common return circuit opens the locking circuit of these relays. They are therefore de-energized and their contacts are released and returned to their normal position. This in turn releases the selecting magnets, but those that have been selected cannot yet return to their normal position because the selecting discs are now locked, so to speak, by the vertical arm of the stunt bar which is in the selected slot.

23. The circuit established through the overlap relay causes this relay to operate, but the retardation coil in series with this relay purposely delays its action to permit the operation of some of the other functions first before the circuits controlled by the overlap relay are disturbed. Let us therefore leave this relay for the present, and complete the selection and printing of the letter "E."

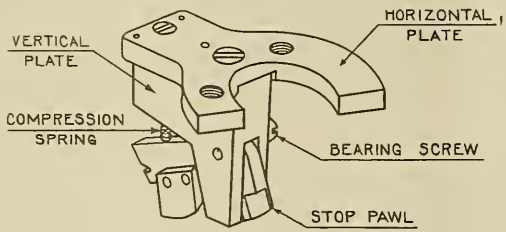



Fig. 8

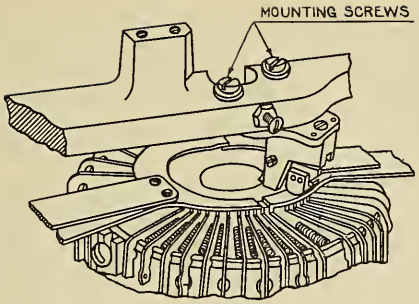



Fig. 9

24. The third function of the release magnets is the operation of the mechanical start unit. This unit, which is shown in Figures 8 and 9, is mounted directly above the right hand release arm. A pawl on the start unit normally engages the striking arm on the typewheel and thus prevents the typewheel from rotating. As the right hand release arm moves up, it engages the pawl on the start unit and forces it out of the path of the striking arm. This permits the typewheel to rotate, under the action of the winding spring, until the striking arm engages the tip of the "E" stop bar which is now in its path. This stops the typewheel in such a position that the letter "E" is directly opposite the paper on which it is to be printed.

25. By the time the rotation of the typewheel is completed the overlap relay has closed its contacts. The positive battery on the left hand tongue is therefore disconnected from the selecting contact common return circuit and connected through the front contact to the selecting relay common return. This restores the selecting relay circuit, thus making it possible to operate these relays from the line impulses next received, even if the printing operation has not been quite completed. The right hand contacts close a circuit which starts at the positive battery connected through the frame of the printer to the stop bar.

26. When the striking arm stops against the stop bar, the positive battery on the stop bar is connected through the striking arm to the printing magnet through the right hand contact of the overlap relay, one of the coils on the space lock relay, the clearout circuit common return, the coil of the clearout relay to negative battery.

27. This causes the printing magnet to operate, which forces the paper against the typewheel, thus printing the selected letter.

28. The current impulse through the printing magnet, as we have seen, also passes through the space lock relay and the clearout relay.

29. The space lock relay operates, thus closing both of its contacts. One of these contacts closes a locking circuit, thus permitting current to flow from positive battery to one of the coils on the relay, through the locking contact, thence to the spacer magnet contact and negative battery. The second contact on the space lock relay closes a circuit from positive battery on the tongue, through the spacer magnet, to negative battery. The spacer magnet is therefore energized. Its operation causes the printer carriage to be spaced to the proper position for printing the following letter. The spacing unit will be described later in greater detail; for the present it is sufficient to know how the spacing unit is energized. When the spacer magnet operates, it breaks a contact in the space lock relay locking circuit, thus de-energizing this circuit.

30. We will return now to the clearout relay which was energized at the same time as the space lock relay and printer magnet. The function of this relay is to cause the resto-

ration of the printer circuits to their normal positions, since the printing of the letter "E" has now been completed.

31. We already have seen that the selecting relays and selecting magnets have been de-energized by the operation of the right hand release arm contacts. The object in releasing these relays and magnets before the printing of the letter was actually complete was to give the printer more time to perform its functions. As soon as the relays are released they become free to receive a second set of impulses while the printing of the first set of impulses is being completed.

32. When the clearout relay breaks its contact the circuit through the release magnets is broken. This causes these magnets to release their semicircular arms, which then press down all the stop and stunt bars, forcing out the one in the slot, thus releasing the discs, selecting magnets and the typewheel. The typewheel rotates until the striking arm is caught by the start unit pawl. This holds it ready for the next selection.

33. The de-energization of the release magnets also causes the contacts on the right hand release magnet armature to be restored to normal, thus re-establishing the normal circuit of the selecting relay common return. It should be mentioned here that since the selecting relays were restored to their normal position their common return circuit has been kept closed by the left hand front contact of the overlap relay. This path is now broken, after the normal path has been restored, by the operation of the release magnet contacts which open the circuit to the overlap relay.

34. The breaking of the right hand contact on the overlap relay opens the circuit through the space lock relay, and since the locking circuit on this relay is opened by the operation of the spacer magnet, this relay is de-energized when the spacer magnet operates and restored to normal. This completes the operation of the printer in selecting and printing the letter "E."

35. The description of the operation of the printer just completed is, of necessity, long, and consequently upon reading it for the first time one is apt to become confused. In order, therefore, to compose our ideas of the printer's operation let us review briefly the sequence of the operations that we have just traced for the printing of the letter "E."

36.
1. No. 1 selecting relay operated.
2. Release control relay operated.
3. No. 1 selecting magnet operated.
4. No. 1 selecting disc rotated.
5. Printing relay operated.
6. Release magnets operated.
7. Stop bar representing the letter "E" falls in slot.
8. Selecting relay released.
9. Selecting magnet de-energized.
10. Start unit operated.
11. Typewheel shaft released.
12. Overlap relay operated.
13. Contact between the striking arm and the "E" stop bar established.
14. Printer magnet operated.
15. Space lock relay operated.
16. Clearout relay operated.
17. Spacer magnet operated.
18. Normal.

37. The operation of printing any letter or character is similar to the operation described for the letter "E." The only difference is in the selection of the different discs called for by the combination representing the desired letter.

38. If we wish to perform some function other than printing, however, the operation is modified somewhat, but before we describe their operation it might be well to consider briefly the function units themselves. We will consider in this connection the printing unit also.

39. The printing unit shown in Figure 10 consists of a magnet, armature, and printing hammer so mounted that when the magnet is energized the armature imparts to the hammer a forward motion which causes the hammer to strike a quick blow on the letter of the typewheel which is opposite the hammer. The paper on which the message is to be printed is inserted between the hammer and typewheel so that an imprint of the letter is made on the paper.

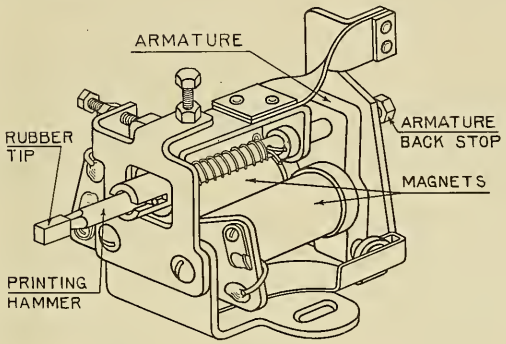



Fig. 10

40. The spacer unit is shown in Figure 11. Its function is to space the carriage of the printer the correct distance after the printing of each letter or whenever it is desired to make a space, as between words.

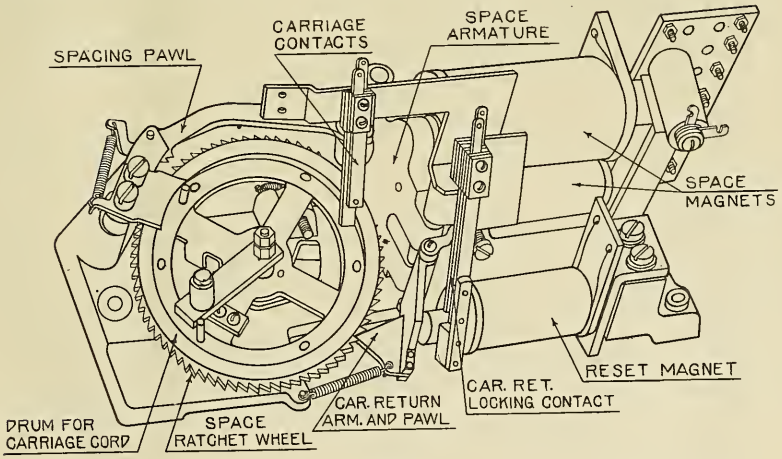



Fig. 11

41. The carriage is normally held to the extreme right of the printer by means of a cord, one end of which is fastened to the carriage and the other end wound on a small drum which is under the tension of a spiral drum spring. When the spacer magnet is operated it draws the carriage to the left against the tension of this spiral spring.

42. The spacer unit consists of a magnet, which by means of its armature and a pawl and ratchet wheel rotates a drum to which is attached a cord, the other end of which is connected to the printer carriage. Each operation of the magnet rotates the ratchet and drum one tooth on the ratchet wheel. This winds up the cord on the drum and pulls the carriage to the left a distance equal to the space required for the printing of one letter, or the space required between consecutive words.

43. To prevent the carriage slipping back when the spacing pawl is not actually in contact with the teeth on the ratchet wheel, a holding pawl is provided.

44. This holding pawl is also a part of the carriage return mechanism, for by releasing this pawl by means of the carriage return magnet, which is placed just back of the pawl, the ratchet wheel and its drum are free to rotate in the counter-clockwise direction. The drum spring therefore rotates its drum, thus winding up the cord and pulling the carriage back to its extreme right hand position.

45. Both the spacer magnet and carriage return magnets are provided with locking circuits and means are provided for opening these circuits when the units have performed their functions. The contacts for opening the spacer magnets already have been mentioned. These contacts are located back of the spacing magnets and therefore are not shown in Figure 11. They are opened when the armature closes, by the engagement of the insulating button on the armature with the extension on the back contact. The carriage return unit has two auxiliary contacts, one directly above the tip of the magnet for closing the locking circuit, and another mounted above the ratchet wheel for opening the same circuit. The first pair of contacts, called locking contacts, is closed when the magnet is energized; the second pair, called carriage contacts, is opened by a stop on the ratchet wheel when it reaches the extreme of its rotation in the counter-clockwise direction.

46. The line feed unit, Figure 12, is located at the extreme right hand side of the printer. As in the case of the spacer unit, this consists of a magnet which by means of an armature and pawl operates a ratchet wheel. This wheel is rigidly attached to the paper platen shaft, so that for each operation of the magnet the shaft is rotated. The rotation moves the paper up the correct distance to space the printing for a new line. As in the case of the other units, the line feed unit is provided with an auxiliary contact. The use of this contact will be described, together with the operation of the line feed circuits in a later paragraph.

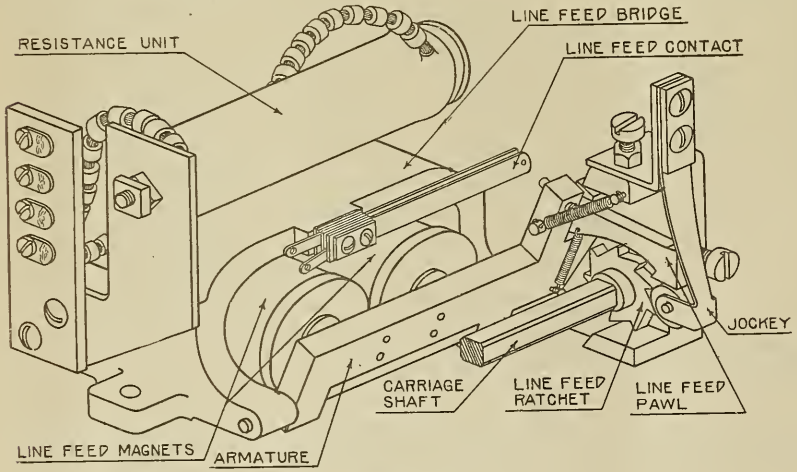



Fig. 12

47. When it is desired to write figures or characters which are in the upper case, the shift unit, Figure 13, must be operated. This unit is located in such a position that an extension of the armature of the shift magnet can engage the typewheel carrier and raise or lower it as determined by the operation of this shift magnet. When the magnet is energized the fibre insulating block on the armature closes the locking contacts mounted on the magnet frame. This keeps the magnet locked with the typewheel in its upper case position until the locking circuit is broken by the operation of the LTRS function.

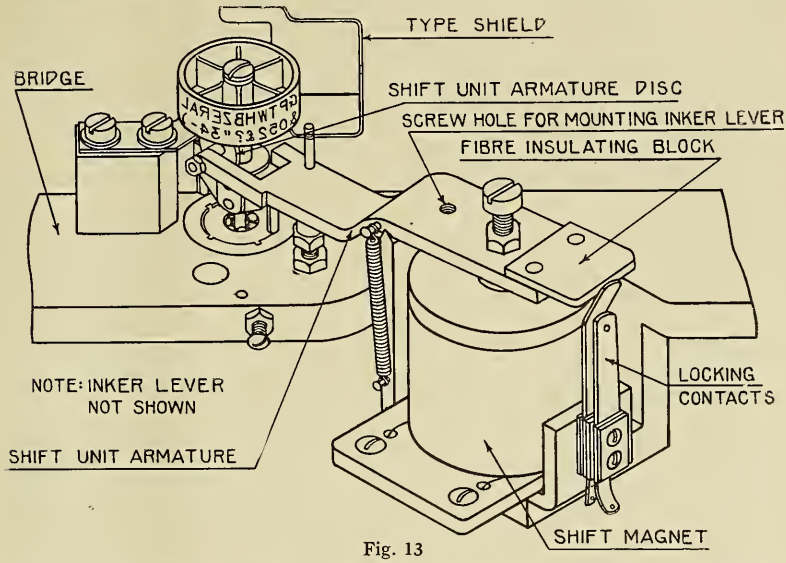



Fig. 13

48. For signalling purposes a bell is provided on the printer, which is operated whenever the characters representing Figures J and Letters are successively sent to the printer. The bell and the relay which controls it are located in the relay box. Its operation will be described in a later paragraph.

49. Let us now return to our circuit diagram, Figure 7, and trace the operation of the circuits which control some of these function units that we have described. Let us begin with the space function.

50. To select this function only the third selecting relay must be operated. The printer relay tongue makes contact with the spacing contact during the time the brushes are in contact with the first and second segment. The printer relay reverses as the brush comes in contact with the third segment, thus sending an impulse through the third selecting relay. When the brush passes on to the fourth segment the printer relay has again reversed and continues in contact with the spacing battery for the remainder of the selection. In this manner only the third selecting relay is operated.

51. This relay is operated, locked up, and in turn operates the third selecting disc in the same manner that we traced for the operation of the first selecting relay and disc in the case of the letter "E." When the impulse is received from the local ring the printing relay and release magnets are in turn operated.

52. The operation of the release magnets permits the bar representing the space to fall into its slot. This bar is not a stop bar, similar to the one selected for the letter "E," but is instead a stunt bar, which operates a set of contacts. The location of this bar is

shown in Figure 3. The overlap relay is operated by the right hand release magnet contacts, as for the selection of the letter "E." A circuit is now established from positive on the left hand tongue of the overlap relay through the selecting relay common return, the space function, or stunt contact, the right hand contact of the overlap relay, one coil of the space lock relay, the common circuit to the clearout relay, the clearout relay coil to negative battery. This operates the space lock relay, thus in turn operating the spacer magnet as was described after the operation of the space lock relay when the letter "E" had been printed. The impulse that operated the space lock relay also operated the clearout relay, which restores the release magnets and consequently the other circuits to normal. During the time the release magnet arms were raised the typewheel was free to rotate, due to the releasing of the striking arm by the mechanical start unit, but since no stop bar was in the path of the striking arm no circuit was established through the printer magnet, hence no letter could be printed. When the release magnets are de-energized through the operation of the clearout relay, the mechanical start unit pawl again catches the striking arm and stops the rotation of the typewheel.

53. To operate the carriage return unit the fourth disc is operated by the line impulses. The printing relay and release magnets are operated in the same manner as for the selection of the letter "E" or the space. When the release magnet operates, the stunt bar representing the carriage return function falls into its slot, thus closing the carriage return stunt or function contact shown in Figure 7. This establishes a circuit from positive battery on one terminal of the carriage return magnet coil through this magnet, the stunt contact, the common circuit to the clearout relay, clearout relay coil to negative battery. This operates the carriage return magnet, thus withdrawing the holding pawl from the ratchet on the space unit. When the magnet is energized a small iron armature mounted on the outside leaf of the locking contacts is attracted by the magnet, thus closing the locking contact which keeps the magnet operated even after the clearout relay has operated and released the release arms. The locking circuit runs from positive battery on one terminal of the coil, through the coil, the locking contacts, the carriage contacts, the resistance R to negative battery. When the carriage has returned to its extreme right hand position a stop on the spacing ratchet opens the carriage contacts, thus opening the locking circuit and returning the holding pawl to its normal position. The impulse through the clearout relay operates that relay, thus restoring the printer to normal, as in the two other selections that have been described. During the time the release magnets were closed the typewheel was free to rotate exactly as it did when the space was selected, but no letter was printed on the paper.

54. It is sometimes necessary to operate the carriage return manually. In order to do this, a push button has been conveniently located on the printer frame. This button, which is connected in parallel with the carriage return stunt contacts, is shown schematically on Figure 7 adjacent to the carriage return stunt contacts.

55. The line feed is operated by selecting only the second selecting disc. This selection and the operation of the printing relay and release magnets are the same as for the functions already described. When the line feed stunt bar falls into its slot a circuit is established from positive battery on the line feed stunt contact through the line feed magnet to negative battery. When the line feed magnet operates, it closes its auxiliary contacts, thus establishing a circuit from positive battery on the auxiliary contact, through the contact, the resistance R1, the common to the clearout relay, the coil of this relay to negative battery. This operates the clearout relay which clears out all the circuits as previously described.

56. The figures function is operated by transmitting to the printer two marking one spacing and two marking impulses; i. e., all but the third selecting disc must be operated. The selection of the four discs and the operation of the printing relay and release magnets are the same as already described for the other functions. The operation of the release magnets permits the figures stunt bar to fall into its slot. This closes a circuit from positive battery on the tongue of the LTRS stunt contacts through the back contact of the LTRS stunt contacts, the coil of the shift magnet, the FIGS stunt contacts, the common to the clearout relay, the coil of this relay to negative battery. This operates the shift magnet which closes its locking contact. This establishes a circuit from the LTRS

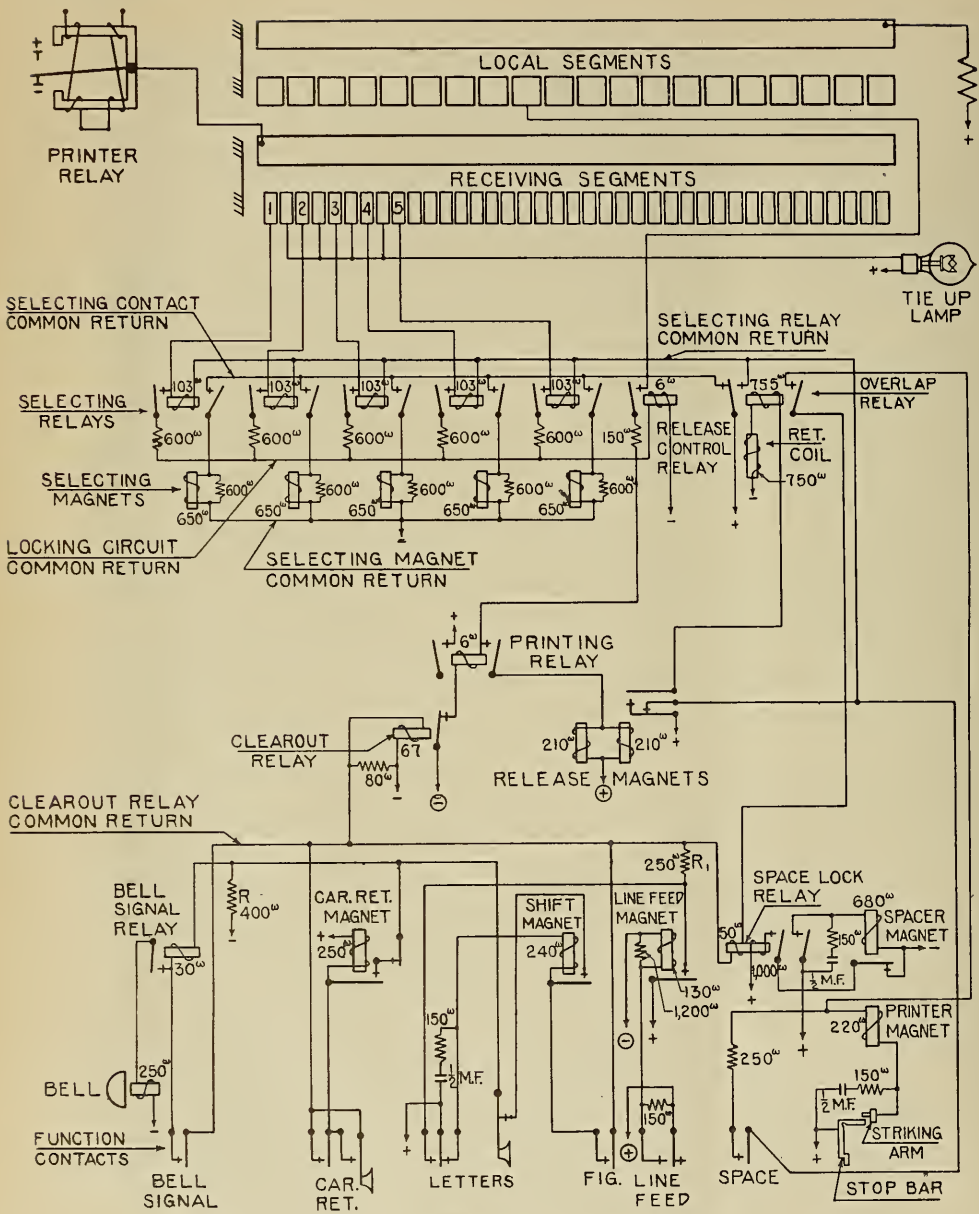
stunt as before through the coil of the shift magnet, the locking contact, a key for manually breaking this locking circuit, through the resistance R to negative battery. Since this circuit is not broken upon the operation of the clearout relay, it is evident that the operation of the clearout relay restores all functions of the printer in the regular manner, but leaves the shift magnet operated and holding the typewheel in the upper case. After this shift has been operated, therefore, the printer continues to write upper case characters until the shift magnet is released. This is done by the LTRS function.

57. The LTRS function is selected by operating all the selecting discs. This and the operation of the printing relay are the same as for the functions already described. When the release arms operate, the LTRS stunt contact falls into its slot. As the tongue of the stunt contact moves away from its back contact it breaks the circuits through the shift magnet. This immediately releases the shift magnet, thus restoring the typewheel to the lower case position. When the tongue makes contact with its front contact it establishes a circuit from positive battery on the tongue of the LTRS stunt contacts through the front contact, the resistance R1 the common circuit to the clearout relay, the coil of this relay to negative battery. The operation of this relay clears the printer as already described.

58. Since it has been found desirable to perform this function manually at times, a push button or key has been placed conveniently on the printer and connected in the shift magnet locking circuit so that its operation opens the circuit through the shift magnet. The push button and its circuit are shown in Figure 7 adjacent to the LTRS stunt contacts.

59. The bell signal is operated by transmitting to the printer three signals. First, a FIGS signal must be sent. This locks the shift magnet in the operated position. A letter "J" is next sent. This letter, as well as the letters "S" and "F," differs from the other letters of the alphabet in the fact that there are two slots lined up for each letter. One of these slots is under the proper letter stop bar, the other under a stunt bar. When the release magnets operate, therefore, both the stop and stunt bar fall in. As soon as the signal bell stunt bar falls into its slot a circuit is established from positive battery on the LTRS stunt contacts through the shift magnet, its locking contact (which was closed by the FIG signal received before the J signal), the manual LTRS key, the coil of the bell signal relay, the bell signal stunt contacts, the common circuit to the clearout relay, the clearout relay to negative battery. It is apparent that the coil of the bell signal relay is in parallel with the resistance R; consequently the current is divided between these two paths. The value of the resistance R is great compared to the resistance of the bell signal and clearout relay, however, so most of the current flows through the latter path. The impulse which flows through the circuit described operates both the clearout and the signal bell relay. The signal bell relay closes its contact and establishes a circuit from the LTRS stunt contact as before through the coil of the shift magnet, the locking contact, the manual LTRS key, the coil of the bell signal relay, its locking contact, the signal bell to negative battery. This gives the signal bell an impulse which is augmented on the opening of the signal bell stunt contacts through the operation of the clearout relay and the restoring of the release arms, etc., in the usual manner. The signal bell relay remains locked up until the LTRS signal is received which releases the shift magnet, thus opening the circuit through the signal bell relay.

60. At the same time that the bell signal stunt bar fell into its slot the letter "J" fell into its slot. The typewheel was released in the usual manner by the mechanical start unit and rotated until the striking arm came in contact with the letter "J" stop bar. The circuit which is closed by the striking arm also passes through the overlap relay. This relay is energized at the same time that the bell signal relay and clearout relay are energized, but due to the fact that the overlap relay is purposely made to be slow in its operation, the bell signal and clearout relay have time to operate before the overlap relay is closed, and since the operation of the clearout relay restores the release arms to their normal position the overlap relay does not have time to close and establish the circuit to the printer magnet before the overlap relay circuit is again broken and restored to normal. For this reason the bell signal only is operated, although the letter "J" stop bar falls in at the same time as the bell signal stunt bar.




THE BATTERY POLARITIES MARKED ⊕ OR ⊖ REMAIN CONSTANT AS SHOWN FOR ALL CHANNELS. ALL OTHER POTENTIALS ARE CORRECT ONLY FOR A AND C CHANNELS. FOR B AND D CHANNELS THESE POTENTIALS ARE REVERSED.

Fig. 14

61. Two functions that would operate in a manner similar to the bell signal are provided for on the letters "S" and "F," but they are not used at present, hence will not be described in these specifications.

62. As a review of the selection and operation of the different letters and functions of the printer the following table showing the sequence of operation for the different functions is given. In connection with these tables Figure 14 is inserted for tracing the circuits. This figure differs from Figure 7 principally in the fact that resistance shunts and condensers, which were omitted from Figure 7 for the sake of simplicity, are included in this drawing. The shunts reduce the current through certain parts of the circuits and retard the operation of some of the relays and magnets. The condensers reduce the arcing at contacts, etc. In the sequence tables for the functions no reference is made to the typewheel or its rotation, since this rotation is only incidental to the performance of the functions and does not enter into either the selection or execution of the function.

63. Letter "E":
1—No. 1 Selecting relay
2—Release control relay
3—No. 1 Selecting magnet
4—No. 1 Selecting disc
5—Printing relay
6—Release magnets
7—Stop bar
8—Selecting relay released
9—Selecting magnet de-energized
10—Starter unit
11—Typewheel rotated
12—Contact between striking arm and the E bar established
13—Overlap relay
14—Printer magnet
15—Space lock relay
16—Clearout relay (1 to 14 released)
17—Space magnet
18—Normal

64. Space:
1—No. 3 Selecting relay
2—Release control relay
3—No. 3 Selecting magnet
4—No. 3 Selecting disc
5—Printing relay
6—Release magnets
7—Stunt bar
8—Stunt contacts
9—Selecting relay released
10—Selecting magnet de-energized
11—Overlap relay
12—Space lock relay
13—Clearout relay (1 to 11 released)
14—Spacing magnet
15—Normal

65. Carriage Return:
1—No. 4 Selecting relay
2—Release control relay
3—No. 4 Selecting magnet
4—No. 4 Selecting disc
5—Printing relay
6—Release magnets
7—Stunt bar
8—Stunt contacts
9—Carriage return magnet
10—Selecting relay released
11—Selecting magnet de-energized
12—Clearout relay (1 to 11 released)
13—Carriage return magnet released
14—Normal

66. Line Feed:
1—No. 2 Selecting relay
2—Release control relay
3—No. 2 Selecting magnet
4—No. 2 Selecting disc
5—Printing relay
6—Release magnets
7—Stunt bar
8—Stunt contacts
9—Line feed magnet
10—Selecting relay released
11—Selecting magnet de-energized
12—Overlap relay
13—Clearout relay (1 to 12 released)
14—Normal

67. Figure Shift:
1—No. 1 Selecting relay
2—Release control relay
3—No. 1 Selecting magnet
4—No. 1 Selecting disc
5—No. 2 Selecting relay
6—No. 2 Selecting magnet
7—No. 2 Selecting disc
8—No. 4 Selecting relay
9—No. 4 Selecting magnet
10—No. 4 Selecting disc
11—No. 5Selecting relay
12—No. 5Selecting magnet
13—No. 5 Selecting disc
14—Printing relay
15—Release magnets
16—Stunt bar
17—Stunt contact
18—Selecting relays released

19—Selecting magnets de-energized
20—Shift magnet operated and locked
21—Clearout relay (1 to 19 released)
22—Normal

68. Letters:
1—No. 1 Selecting relay
2—Release control relay
3—No. 1 Selecting magnet
4—No. 1 Selecting disc
5—No. 2 Selecting relay
6—No. 2 Selecting magnet
7—No. 2 Selecting disc
8—No. 3 Selecting relay
9—No. 3 Selecting magnet
10—No. 3 Selecting disc
11—No. 4 Selecting relay
12—No. 4 Selecting magnet
13—No. 4 Selecting disc
14—No. 5 Selecting relay
15—No. 5 Selecting magnet
16—No. 5 Selecting disc
17—Printing relay
18—Release magnets
19—Stunt bar
20—Stunt contacts
21—Shift magnet released
22—Selecting relays released
23—Selecting magnets de-energized
24—Clearout relay (1 to 23 released)
25—Normal

69. Bell Signal. After sequence for Figure Shift:
1—No. 1 Selecting relay
2—Release control relay
3—No. 1 Selecting magnet
4—No. 1 Selecting disc
5—No. 2 Selecting relay
6—No. 2 Selecting magnet
7—No. 2 Selecting disc
8—No. 4 Selecting relay
9—No. 4 Selecting magnet
10—No. 4 Selecting disc
11—Printing relay
12—Release magnets
13—Stunt bar
14—Stunt contacts
15—Selecting relays released
16—Selecting magnets de-energized
17—Bell Signal relay operated
18—Clearout relay (1 to 16 released)
19—Bell tapped
20—Normal with shift magnet and signal bell relay locked up

NOTE: The above sequence is followed by the Letter Signal which restores the shift magnet and the signal bell relay to normal.

70. The reliable operation of the printer depends upon the proper functioning of all its various circuits, relays and magnets. A failure of a relay to operate or a fault in one of the circuits, as, for instance, an open circuit in the printing relay, might cause the printer to stop entirely or "tie up." If such a fault were not quickly detected the sending station might continue to send, although its messages were not being received at the other end of the line. To prevent such an occurrence a "tie up" lamp is provided in the printer.

71. This lamp is operated by the receiving segments on the distributor which are not used for selection, as was mentioned in Section 2. It is so connected that it flashes continuously when marking impulses are sent to the printer, but does not flash when spacing impulses are sent. Since the printer should operate when marking impulses are sent to it, it should operate whenever the lamp flashes, and if it does not it is an indication that the printer is tied up.

72. The lamp circuit is not shown on Figure 7 but may be traced on Figure 14 and also on Figure 15 which is an actual wiring diagram of the printer. The numbered clips at the bottom of the diagram are the table clips which serve to connect the printer to the distributor and battery connections as well as to connect it with the relay bank, the wiring diagram of which is shown in Figure 16.

73. Clips one to five, Figure 15 and Figure 16, are connected to the receiving segments of the distributor; clip six is the impulse from the local ring, commonly called the 6th pulse. Clips 7 to 25, inclusive, serve only as connectors between the printer and the bank, 26 is connected to the tie up lamp segments on the distributor, and 31 is a battery connection, the polarity of which is opposite to the polarity received on 26 when marking impulses are sent to the printer. Clip 27 is positive battery, 28 negative battery; 29 and 30 are also battery taps, their polarities depending upon a channel where the printer is to be operated.

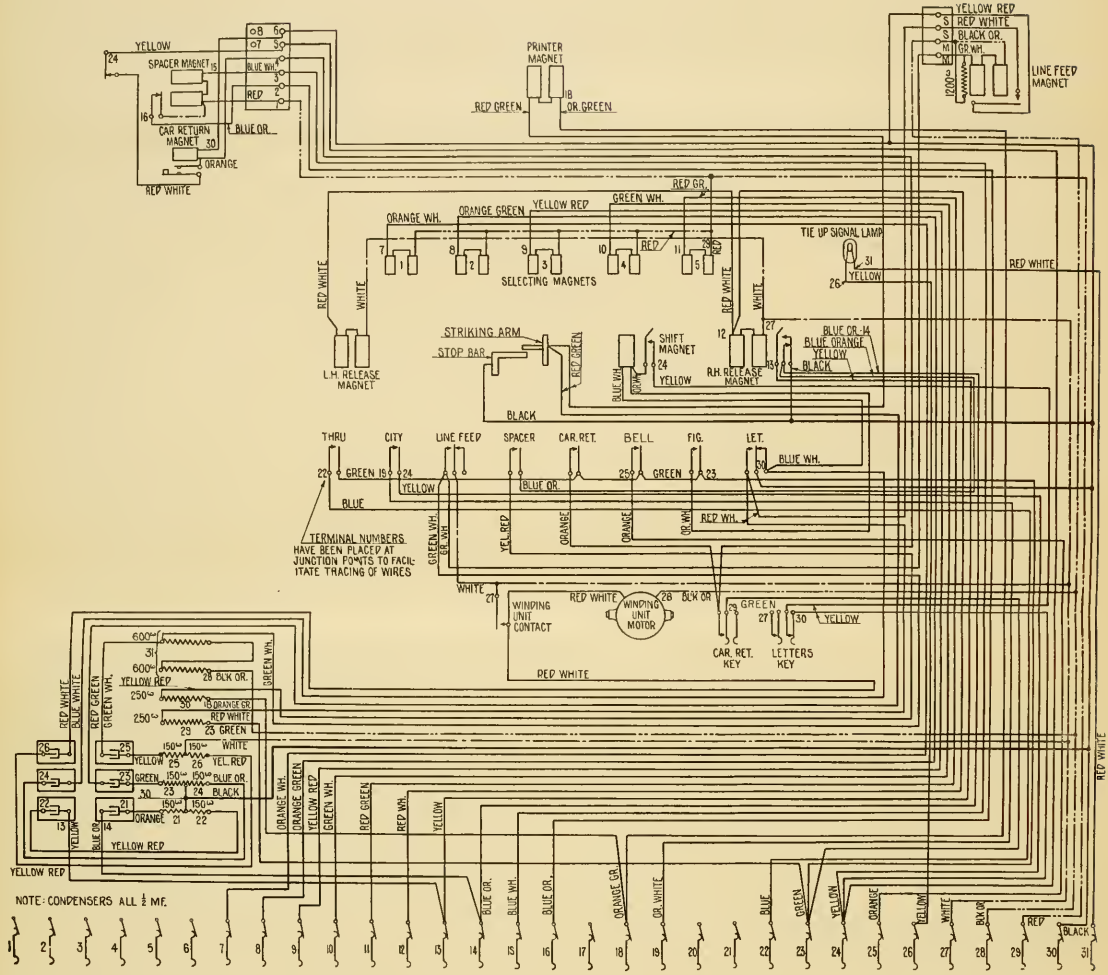

YELLOW
SPACER MAGNET
BLUE WH.
RED
CAR RETURN MAGNET
BLUE OR.
ORANGE
RED WHITE
PRINTER MAGNET
RED GREEN
OR. GREEN
YELLOW RED
RED WHITE
BLACK OR.
OR WH.
LINE FEED MAGNET
RED GR.
ORANGE WH.
ORANGE GREEN
YELLOW RED
GREEN WH.
RED
SELECTING MAGNETS
TIE UP SIGNAL LAMP
YELLOW
RED WHITE
WHITE
L.H. RELEASE MAGNET
STRIKING ARM
STOP BAR
RED GREEN
SHIFT MAGNET
R.H. RELEASE MAGNET
BLUE OR. 14
BLUE ORANGE
YELLOW
BLACK
BLUE WH.
GREEN
YELLOW
BLACK
THRU
CITY
LINE FEED
SPACER
CAR. RET.
BELL
FIG.
LET.
GREEN
BLUE WH.
BLUE OR.
BLUE
ORANGE
OR WH.
RED WH.
YEL. RED
GREEN WH.
RED WH.
TERMINAL NUMBERS HAVE BEEN PLACED AT JUNCTION POINTS TO FACILITATE TRACING OF WIRES
WHITE
WINDING UNIT CONTACT
RED WHITE
WINDING UNIT MOTOR
BLK OR
GREEN
YELLOW
CAR. RET. KEY
LETTERS KEY
RED WHITE
600Ω
YELLOW RED
BLK OR.
GREEN WH.
250Ω
ORANGE GR.
RED WHITE
RED GREEN
BLUE WHITE
GREEN WH.
150Ω
WHITE
YELLOW
YEL. RED
GREEN
BLUE OR.
BLACK
ORANGE
YELLOW
BLUE OR.
ORANGE WH.
ORANGE GREEN
YELLOW RED
GREEN WH.
RED GREEN
RED WH.
YELLOW
BLUE OR.
BLUE WH.
ORANGE GR.
OR WHITE
BLUE
GREEN
YELLOW
ORANGE
YELLOW
WHITE
BLK OR
RED
BLACK
NOTE: CONDENSERS ALL ½ MF.

Fig. 15

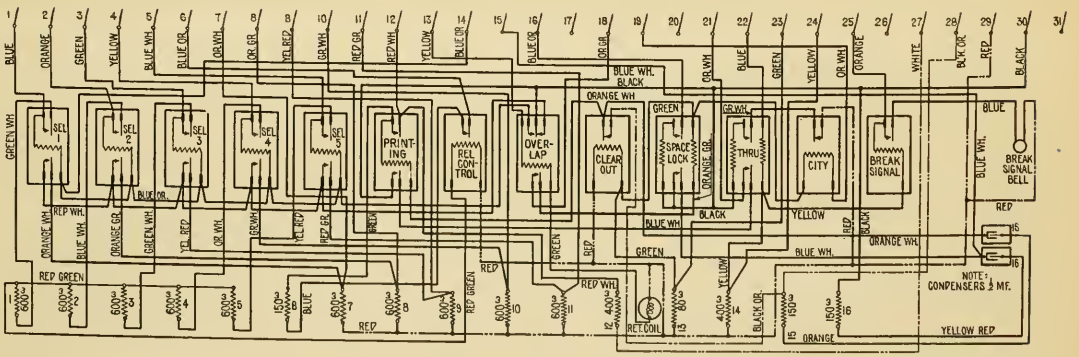

BLUE
ORANGE
GREEN
YELLOW
BLUE WH.
BLUE OR.
OR WH.
OR GR.
YEL RED
GR WH.
RED GR.
RED WH.
YELLOW
BLUE OR.
BLUE OR.
ORANGE GR.
OR WHITE
BLUE
GREEN
YELLOW
OR WH.
ORANGE
WHITE
BLK OR.
RED
BLACK
GREEN WH.
SEL 1
SEL 2
SEL 3
SEL 4
SEL 5
PRINTING
REL. CONTROL
OVER-LAP
CLEAR OUT
SPACE LOCK
THRU
CITY
BREAK SIGNAL
BREAK SIGNAL BELL
BLUE WH.
BLACK
ORANGE WH
GREEN
GR.WH.
ORANGE GR.
BLUE
RED
RET. COIL
NOTE: CONDENSERS ½ MF.
YELLOW RED

Fig. 16

## ADJUSTMENTS

1. **General.** Before adjusting, the printer shall be thoroughly cleaned, examined for mechanical or electrical defects, and a thin film of oil applied to all bearing surfaces.

2. **Stop and Stunt Bar Spring Tension.** The stop bar spring shall be adjusted so that the bars will just support tool No. 164 when placed on the bar against its small vertical projection. Line feed and letter stunt bars shall not move on 200 grams but shall move on 225 grams when the scale is applied radially just above the guide plate. Other stunt bars shall not move on 140 grams, but shall move on 170 grams.

3. **Stunt Contacts.** With the release magnet operated and the stunt bars unselected there shall be a clearance of from .003 inch to .007 inch between the fork of the stunt bars and the insulated end of the contact spring. Care in this adjustment insures against the contacts being operated when the different stunt bars are not selected. The break between the normally open contacts of these springs shall be minimum .025 inch, maximum .027 inch. A thickness gauge is furnished for the purpose. In the letters and line feed contacts the normal contact pressure measured just above the rivets in the insulated ends of the contact springs shall be between 40 and 50 grams. For other stunt contact unit springs the pressure of the operating springs against the back stops (contacts), measured as above, shall be between 10 and 15 grams.

4. **Release Magnet Armatures.** The release magnet armatures and arms shall be so set that the clearance betwen the ends of the yokes is about .015 inch. The front opening shall be set midway between the J stop bar and the carriage return stunt bar to prevent either of the bars coming up between the yokes. With this adjustment of the release arms the projections on the top of the stop and stunt bars will be under the center line of the yokes. With the release magnets operated (by hand) and the yokes raised, there shall be a clearance of .015 inch between the yokes and any stop bar that may have been selected. This means that with the release arm yoke at its highest operated position, and a selected stop bar also in its operated (raised) position, the yoke will be clear of the projection on the stop bar by .015 inch. This adjustment of the release arm yokes is effected by bending the arms at their fulcrum bearing.

5. **Release Arm Retractile Springs.** Turn down the right hand compression spring nut until all the stop bars are pushed down by the yoke when the armature is raised and slowly released by hand, then give it another three-quarter turn. Repeat this operation with the left hand release magnet arm. Do not put more tension on the release arm springs than is required, as this tends to slow down the printer and also causes undue wear of the associated parts.

6. **Release Arm Contact Springs.** The contact springs of the right release unit shall be adjusted as follows:

Normal contact break minimum .010 inch.
Operated contact break minimum .010 inch.
Normal contact pressure minimum 100 grams.

The operating spring must bear against the fibre of the release magnet armature with a maximum pressure of 100 grams.

7. **Selecting Unit Retractile Spring.** The retractile spring of the selecting magnet when stretched to a length of one inch shall have a tension of from 275 to 310 grams.

8. **Selecting Unit Position.** Adjust the unit relative to the discs so that the end of the reed shall not bottom in the slot in the disc nor swing out beyond the middle of the eye. Adjust the unit so that with a .012 inch gauge placed between the armature and the polepiece, and with the armature closed, the disc will be held firmly against the front stop. When an .018 inch gauge is placed in the same position and under the same conditions the disc shall not come up to the front stop.

9. **Selecting Unit Armature Stop Screw.** Adjust the back stop screw of the magnet armature so that there is a clearance of .005 inch between the armature and the stop screw when the armature is in its unoperated position.

10. **Space and Carriage Return Unit Position.** The complete unit shall be set on the platform as far as possible toward the front of the printer. The carriage return unit shall be so set on the base that with the armature operated, its pawl clears the circumference of the ratchet wheel .010 inch to .020 inch at the point of minimum clearance, if there is any eccentricity. With the space magnet operated, adjust the carriage return unit by means of the screw bearing against the framework post, so that there will be a clearance between the teeth of the wheel and the carriage return pawl of .005 inch to .010 inch. This adjustment shall be made at a point in the rotation of the wheel where the clearance is minimum, if there is any appreciable variation.

11. **Carriage Return Armature Retractile Spring.** The tension of the carriage return armature retractile spring shall be 3 to 4 ounces.

12. **Ratchet Wheel Back Stop Screw.** Adjust the back stop of the ratchet wheel so that the carriage return pawl will engage the third tooth when the carriage is in a normal position, with the clearance mentioned.

13. **Space Pawl.** With the space armature retracted, adjust the space pawl so that there is .010 inch to .020 inch clearance between the teeth of the pawl and the ratchet wheel, measured at a point of the wheel's rotation where this clearance is minimum, if there is any variation. Upon operating the armature, the teeth of the pawl shall strike the face of the teeth of the wheel one-third to one-half of the radial length from the root. The adjustment of the pawl shall be such that when the armature is against the magnet cores the locking pin shall be free from the back of the head or pawl end. The adjustment must never be made so that the pawl will in any way cause the armature to stop before touching the cores of the magnet.

14. **Space Armature Retractile Spring.** The tension of the space armature retractile spring shall be 85 to 110 grams.

15. **Space Pawl Spring.** The tension of the space pawl spring shall be between 15 and 30 grams.

16. **Space Clearout Contacts.** With the space magnet armature operated and a .030 inch gauge between the armature and the polepiece the contacts shall not open; but with a .025 inch gauge in the same position the contact shall open. The contact pressure shall be 50 grams minimum.

17. **Carriage Return Contact Springs.** With the carriage in normal position there shall be a contact break of not less than .010 inch. The contact shall close on that part of the revolution of the ratchet wheel represented by one-half tooth from the starting point. The contact pressure shall be between 125 and 200 grams.

18. **Carriage Return Locking Springs.** Forty grams minimum pressure applied at the top of the fibre insulator shall be required to push the operating spring away from its back stop. The normal contact break shall be between .015 inch and .020 inch. With a .015 inch gauge in the minimum air gap the contact shall close when the armature is pushed toward the core.

19. **Carriage.** The carriage shall move freely on the square shaft with the retractile spring tension removed. The pull to start the carriage (without tension) at any point of the square shaft shall be not over 85 grams. The shaft shall be kept clean and covered with a thin film of oil.

20. **Carriage Cord.** The carriage cord shall be replaced as soon as a chafed spot is noticed and not left until it breaks.

21. **Roll Hanger Springs.** The springs holding the feed roll against the cylinder shall be adjusted to a tension of 140 to 150 grams; that is, a pull of this value applied in line with the springs shall be just sufficient to pull the roll away from the cylinder. If the paper does not feed evenly, it will probably be found that the tensions of the roll hanger springs are not alike.

22. **Carriage Return Spring.** With the paper carriage at the right end of its travel adjust the carriage return spring so that a pull of 200 to 225 grams is required to start the carriage against the spring tension. The carriage return cord shall be adjusted to such a length that there is a gap of 1/8 inch between the carriage and the bumper with the carriage in its normal position.

23. **Line Feed Pawl Retractile Spring.** The tension of the line feed pawl retractile spring shall be from 15 to 30 grams, applied to the end of the pawl.

24. **Line Feed Armature Retractile Spring.** The tension of the line feed armature retractile spring shall be from 310 to 340 grams.

25. **Line Feed Clearout Contacts.** With a .015 inch gauge placed between the line feed armature and the polepiece the clearout contacts shall not close when the armature is operated. With a .010 inch gauge in the same position the contacts shall close when the armature is operated.

26. **Line Feed Pawl Adjusting Screw.** With the armature operated, turn down the line feed pawl adjusting screw so it just touches the line feed pawl.

27. **Line Feed Armature Adjusting Screw.** With friction applied to the carriage cylinder and the line feed armature unoperated, adjust the line feed armature adjusting screw to give approximately .030 inch clearance between the face of the pawl and the apex of all ratchet teeth.

28. **Shift Unit Position.** Set the unit so the disc will not bear against the sleeve of the typewheel carrier.

29. **Typewheel Lower Case Adjusting Screw.** With the shift magnet de-energized, adjust the typewheel lower case adjusting screw so that the typewheel in its lower position is 11/64 inch above the horizontal surface of the type shield.

30. **Typewheel Upper Case Adjusting Screw.** Adjust the typewheel upper case adjusting screw so that a .075 inch gauge will just be admitted between the screw end and the core.

31. **Shift Unit Armature Retractile Springs.** Adjust the shift unit armature retractile springs so that their tension is balanced by 140 to 170 grams with the pressure applied downward on the top of the stop screw.

32. **Shift Unit Contacts.** The shift unit locking contacts shall be adjusted so that the operating spring shall rest against the fibre cam with a pressure of 15 grams maximum. With a .015 inch gauge between the stop screw and the core, the locking contacts shall not make with the armature operated. With a .010 inch gauge in the same position, the contacts shall make with the armature operated.

33. **Dynamometer Spring Tension.** The torque of the typeshaft is controlled by the tension of the dynamometer spring. This spring shall be adjusted so that when the main spring is fully wound the torque of the typewheel will exert a pull of 70 to 100 grams measured tangentially at the leg of the carrier. To wind the main spring fully, operate the start unit and hold it operated until the motor reaches a steady speed and then release it. This measurement shall be made with the pressure of the ink roller removed from the typewheel.

34. **Mechanical Start Unit.** The start unit is held in position by two screws through the bridge near the type shaft. Its position relative to the crown shall be such that when the type shaft is held by the stop pawl, the face of the striking arm is .020 inch behind any slot in the center guide or circular comb.

35. **Type Shield.** Move the type shield as far as possible to the right. Set it parallel to the paper carriage shaft in such a position as to give .010 inch clearance between the inside of the shield and the face of the typewheel.

36. **Printing Unit Position.** Operate the printing magnet. The printing unit shall then be set to give .030 inch clearance between the face of the rubber cap on the end of the printer hammer and the back surface of the type shield.

37. **Printing Unit Armature Back Stop.** Adjust the back stop so that there is a gap of .075 inch between the armature and its back stop.

38. **Print Hammer Retractile Spring.** The tension of the print hammer retractile spring shall be from 45 to 55 grams with the armature in its operated position.

39. **Printing Hammer Guide.** Select the letter "E." Adjust the printing hammer guide laterally in line with the letter "E" and vertically so that the bottom edge of the rubber cap comes halfway between the upper and lower rows of typewheel characters. As a check, the print hammer cap and the type shield should be .030 inches apart.

40. **Typewheel Position.** The correct position of the typewheel on the type shaft is with the letter "T" in line with the larger end of the striker arm.

41. **Type Crown.** The accuracy of the printer depends largely upon the correct working of the parts associated with the crown. These parts are the selecting magnets, selecting discs, stop bars, stunt bars, and the type shaft and its projecting arm. The selecting magnet armatures and the discs must be perfectly free. The discs, when in their normal or non-operated position, shall be held firmly against the back stop and when rotated by their respective magnets shall be held firmly against the front stop.

42. The springs on the printer magnets shall be adjusted as shown in the following table, which gives also the winding constants of the coils:

| MAGNETS | COILS PER MAGNET | TURNS | WIRE | RES. OHMS ±5% | SPRING TENSION | REMARKS |
|---|---|---|---|---|---|---|
| R. H. Release | 2 | 4000 | 30 B.E.C.C. | 105 | | Sufficient to push down stop bars when armature is slowly released by hand, plus 3/4 turn of nut. |
| L.H. Release | 2 | 4000 | 30 B.E.C.C. | 105 | | |
| Selecting | 2 | 4200 | 32 B.E.C.C. | 325 | 10 to 11 oz. | When extended one inch. |
| Space | 2 | 8400 | 33 B.E.C.C. | 340 | 3 to 4 oz. | |
| Car. Return | 1 | 5000 | 35 B.E.C.C. | 250 | 3 to 4 oz. | |
| Line Feed | 2 | 3800 | 29 B.E.C.C. | 63 | 11 to 12 oz. | |
| Shift | 1 | 6900 | 32 B.E.C.C. | 240 | 5 to 6 oz. | Pressure applied on stop screw. |
| Printer | 2 | 3600 | 34 B.E.C.C. | 110 | 1½ oz. to 2 oz. | |

43. The relays shall be adjusted to the values shown in the following table, which gives also the winding data. The contact spring shall be set first and the relay then made to operate on the correct current value as given in the table. Special tools are provided for bending the relay springs to obtain the proper tensions.

| RELAYS | COILS PER RELAY | ARMATURE TRAVEL | TURNS | WIRE | RES. OHMS ±5% | OPERATING REQUIREMENTS AMPERES OPER. | NOT OPER. | REMARKS |
|---|---|---|---|---|---|---|---|---|
| Selector | 1 | .012″ | 4200 | 33 B.E.C.C. | 103 | .030 | .025 | Contacts make with arm. .006″ from core. |
| Rel. Control | 1 | .020″ | 1050 | 27 B.E.C.C. | 6 | .080 | .070 | Contacts make with arm. .008″ to .010″ from core. |
| Overlap | 1 | .025″ | 10000 | 38 B.E.C.C. | 755 | .045 | .040 | Contacts make with arm. .008″ to .010″ from core. |
| Clearout (Shunt off) | 1 | .035″ | 3500 | 32 B.E.C.C. | 67 | .080 | .070 | Contact break .020″. |
| Clearout (Shunt on) | 1 | .035″ | 3500 | 32 B.E.C.C. | 67 | .147 | .128 | Contact break .020″. |
| Printer | 1 | .012″ | 1050 | 27 B.E.C.C. | 6 | .200 | .170 | Contacts make with arm. .006″ to .008″ from core. |
| Sp. Lock | 2 | .020″ | 2040<br>2000 | 33 B.E.C.C.<br>38 B.E.C.C. | 50<br>1000 | .090 | .080 | Contacts make with arm. .008″ to .010″ from core. |
| Break Signal | | .020″ | 2400 | 30 B.E.C.C. | 30 | .060 | .055 | Contacts make with arm. .008″ to .010″ from core. |

**44. Cable Form.** For convenience in wiring printers in which the cable form must be replaced, Figure 17, which shows the cable form, is here inserted.

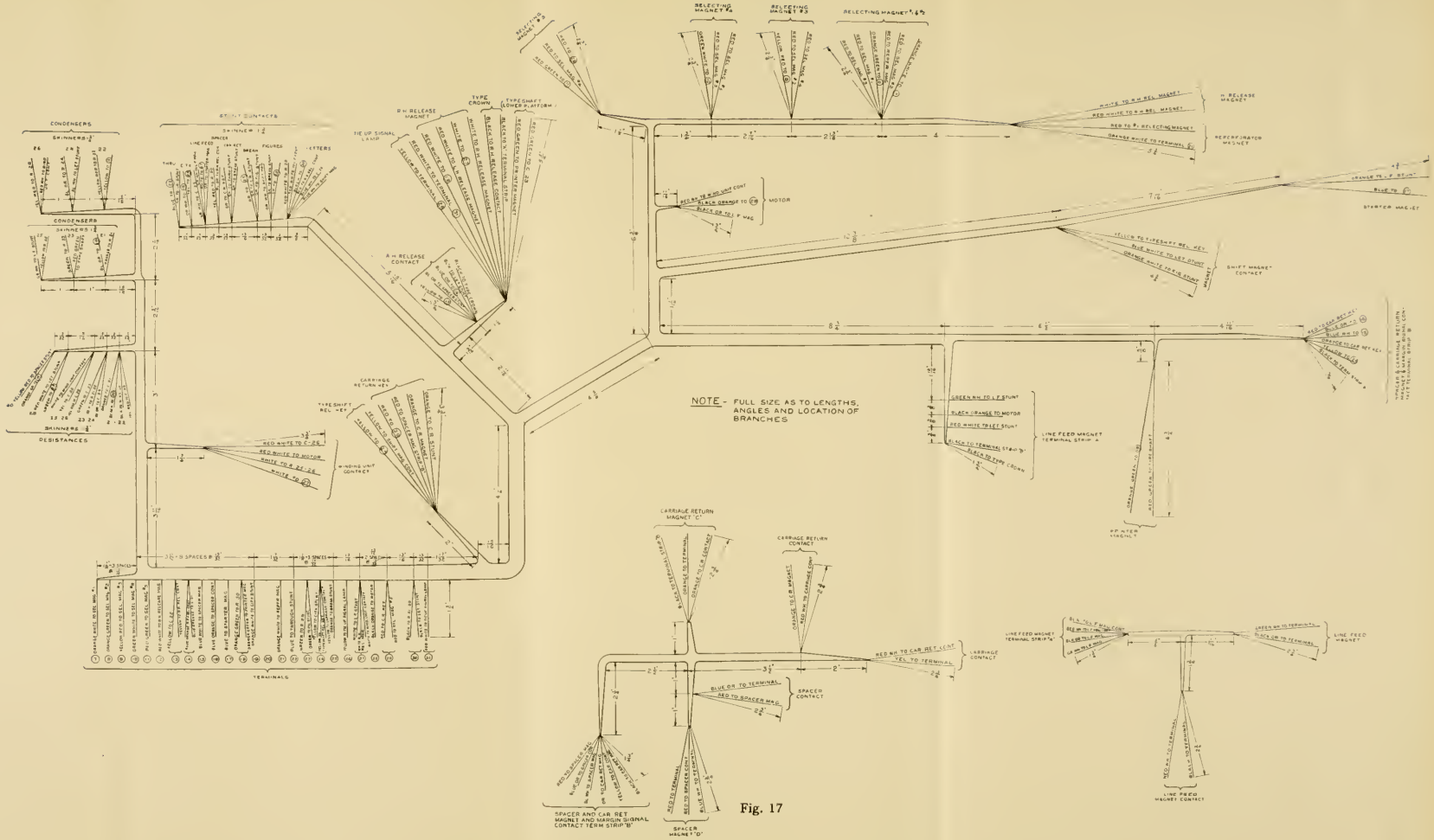

NOTE - FULL SIZE AS TO LENGTHS, ANGLES AND LOCATION OF BRANCHES
SPACER AND CAR. RET MAGNET AND MARGIN SIGNAL CONTACT TERM STRIP 'B'
SPACER MAGNET 'D'
LINE FEED MAGNET CONTACT

Fig. 17

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 5-A

PRINTER 5-A

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These Specifications are the property of the Western Union Telegraph Company and shall not be published.

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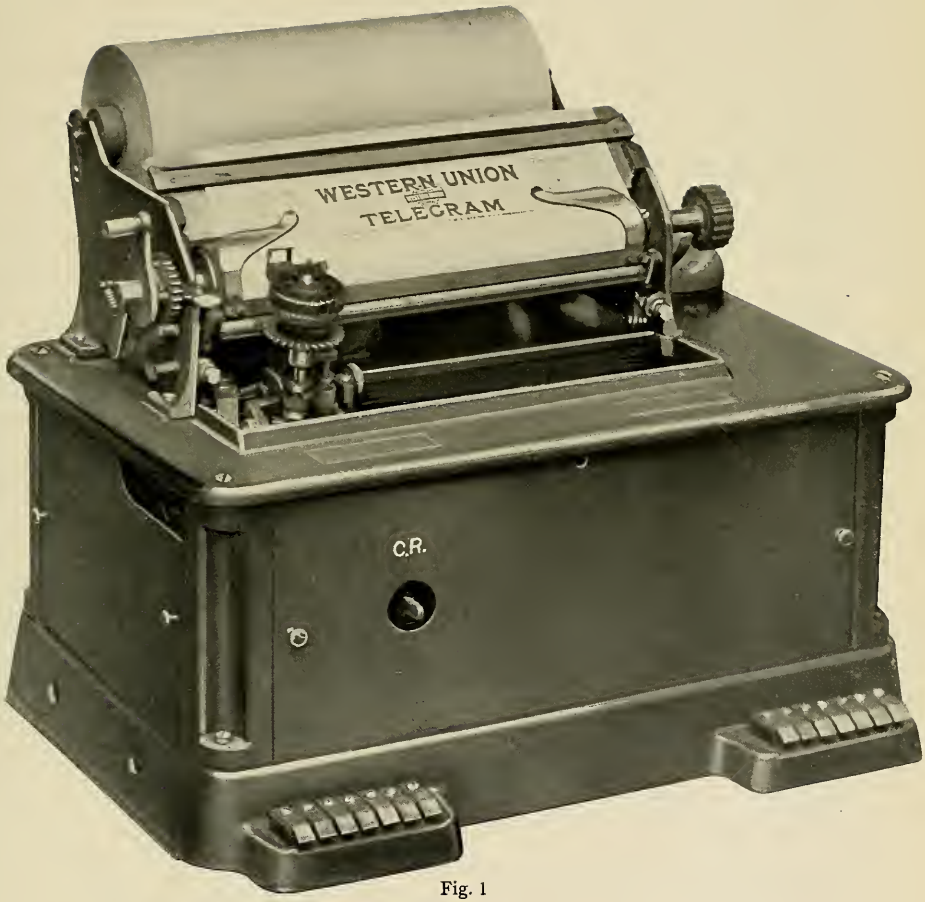



Fig. 1

## MULTIPLEX PRINTER 5-A

1. In the theoretical description of the Multiplex System given in Section 1 the printing of the message was done by a typewriter to which had been attached a selecting unit and other mechanisms. In actual service the printing is done by a unit specially built for this work known as a printer.

2. This section covers the operation and maintenance of Multiplex Printer 5-A, in which the printing is done by means of a typewheel that rotates about a vertical axis and in which the paper moves only for the line feed operation.

3. This printer is interchangeable with all other types of Multiplex printers and is provided with a printer desk, adapter plate and parts adapting it for either roll message paper or cut blanks.

4. Printer 5-A is a typewheel printer in which the characters are arranged in two rows around the periphery of a wheel. By rotating this wheel varying amounts to the left or right of its normal position, any of the characters can be brought to the printing position. A striking mechanism throws the typewheel forward against the paper and platen, and the positioned character is printed. In its motion forward the typewheel strikes an ink roller which rolls across the face of the type, thus inking it. After striking the paper and withdrawing, the typewheel and its carriage is moved one space to the right, in position for printing the next character.

5. The five selecting magnets are connected through the table clips to five segments of the receiving commutator of the distributor. The receiving brush is connected to the tongue of the printer relay. The printer relay is actuated indirectly by the impulses sent over the line and when the impulses are marking, the tongue of the relay will touch its marking contact and connect battery to the receiving brush. As the brush passes over the segments of the commutator it connects the selecting magnets of the printer successively to the tongue of the printer relay and if while any selecting magnet is so connected the line relay tongue is against the marking contact, battery will flow into the selecting magnet and operate it (Fig. 2).

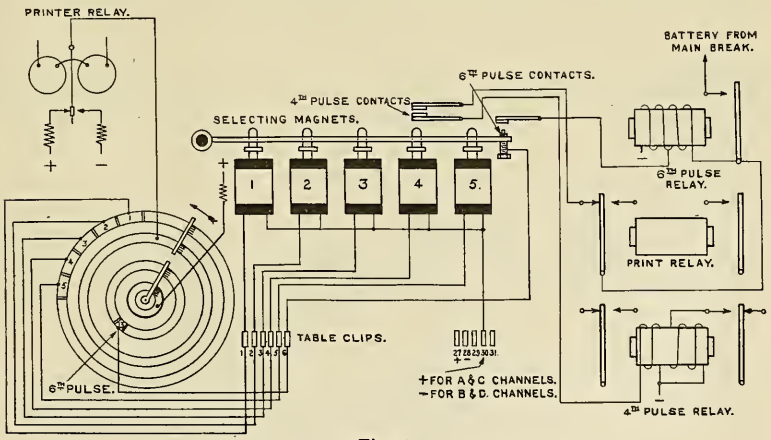



Fig. 2

6. Upon the operation of any of the selecting magnets its plunger is driven forward and disengages its trigger from a trip rod. Each plunger controls a trigger (Fig. 3).

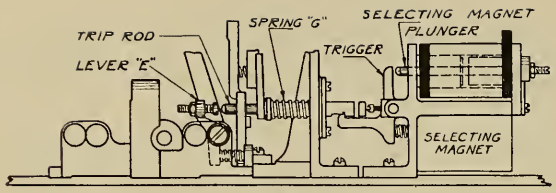



Fig. 3

The spring G, which has been held compressed, now moves the trip rod forward, its collar striking against the reset armature, closing the operating or sixth pulse contacts. The end of all trip rods except the fourth strike against a short lever E which is pinned to a shaft D (Fig. 5). The fourth trip rod closes a fourth pulse contact. This contact determines the direction of rotation of the typewheel (Fig. 4).

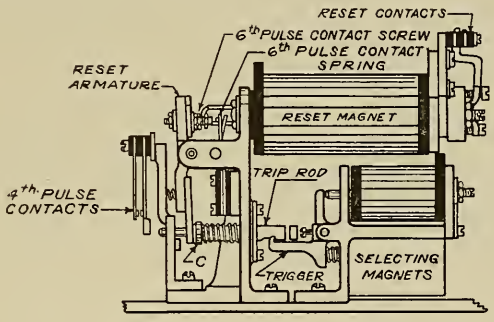



Fig. 4

7. Attached to the shaft D is a long lever C which is slotted at its upper end. This slot engages a pin A on its associated interference plate and controls the rotation of the plate between its two extreme positions which are determined by a slotted lug on the plate (Fig. 5).

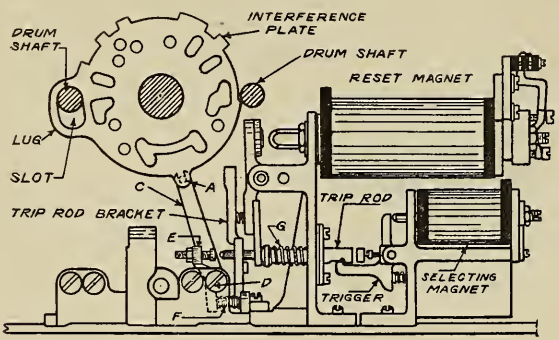



Fig. 5

8. Each of these plates is perforated with a different combination of holes and on the periphery of the upper portion of each are cut various combinations of notches. The movement of one or several of the plates to the operated position will either line up the holes of the four plates to permit passage of two pins, one on either side of the center, or line up the holes for one pin and the notches beneath a function lever. The operation and purpose of the function levers will be explained later.

9. Mounted on the right of the interference plates is the selector, which consists of a drum carrying a number of stop pins and mounted so as to slide upon two horizontal shafts. The stop pins are held against the left hand plate of the drum by springs (Fig. 6).

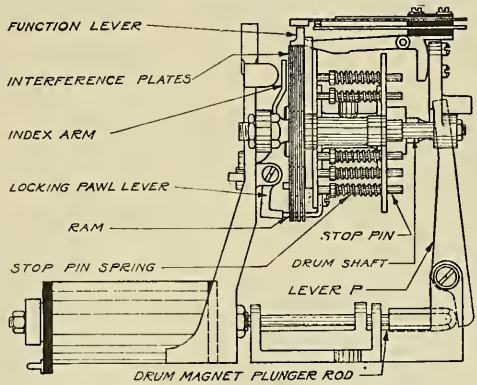



Fig. 6

10. The magnet of the sixth pulse relay is not connected directly to a segment of the distributor, but the circuit to this segment passes through the sixth pulse (operating) contacts controlled by the armature of the reset magnet (Fig. 4).

11. When any selecting magnet is operated and its trip rod released, the collar of this trip rod striking against the reset armature moves the armature and closes the sixth pulse contacts. This completes the circuit from the segment of the distributor to the coil of the sixth pulse relay.

12. When the distributor local brush passes over the sixth pulse segment the sixth pulse relay operates, provided any of the five selecting magnets have operated, thereby allowing battery to flow to the drum magnet and to both tongues of the print relay (Fig. 7). When the drum magnet operates, its plunger presses against a pivoted lever P, thus forcing the upper part of this lever against the drum and moving it to the left. The stop pins are carried with this drum and where a hole is lined up through the four interference plates a pin passes through. Where no holes are lined up the pins are locked and the springs yield.

13. The left hand back contact of the print relay is connected to the fourth pulse contacts and the drum switch. If the fourth pulse contacts have been closed by the operation of the fourth selecting magnet, the fourth pulse relay will now operate. The closing of the drum switch which takes place every time the selector drum operates, connects battery to the reset magnet the plunger rod of which presses against the reset armature and resets the trip rods into engagement with their triggers (Fig. 5).

14. At the same time that battery was connected to the drum magnet it was connected also to one pair of rotator magnets through one of the fourth pulse relay contacts, depending on whether or not this relay was operated (Fig. 8). The fourth pulse relay

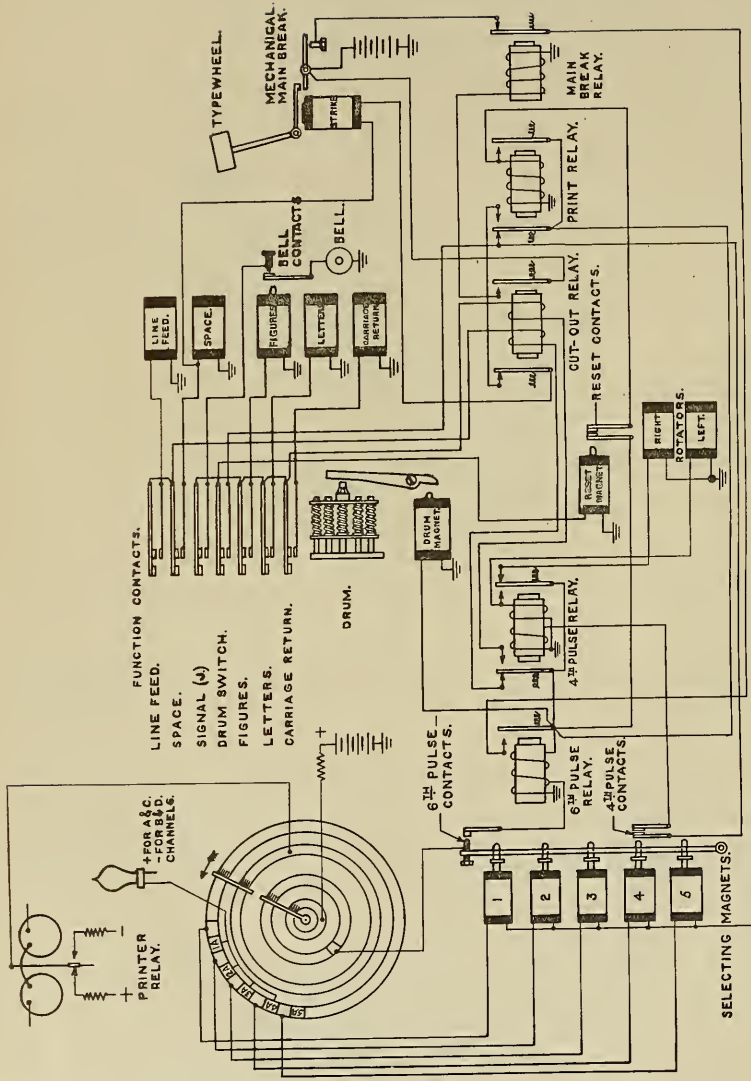

TYPEWHEEL.
MECHANICAL MAIN BREAK.
STRIKE
BELL CONTACTS
BELL.
MAIN BREAK RELAY.
PRINT RELAY.
CUT-OUT RELAY.
RESET CONTACTS.
RIGHT ROTATORS.
LEFT
RESET MAGNET
DRUM MAGNET
LINE FEED.
SPACE.
FIGURES.
LETTERS.
CARRIAGE RETURN.
FUNCTION CONTACTS.
LINE FEED.
SPACE.
SIGNAL (J)
DRUM SWITCH.
FIGURES.
LETTERS.
CARRIAGE RETURN.
DRUM.
4TH PULSE RELAY.
6TH PULSE CONTACTS.
6TH PULSE RELAY.
4TH PULSE CONTACTS.
+FOR A&C.
-FOR B&D.
CHANNELS.
PRINTER RELAY.
SELECTING MAGNETS
+ FOR A&C. CHANNELS.
- FOR B&D CHANNELS.

Fig. 7

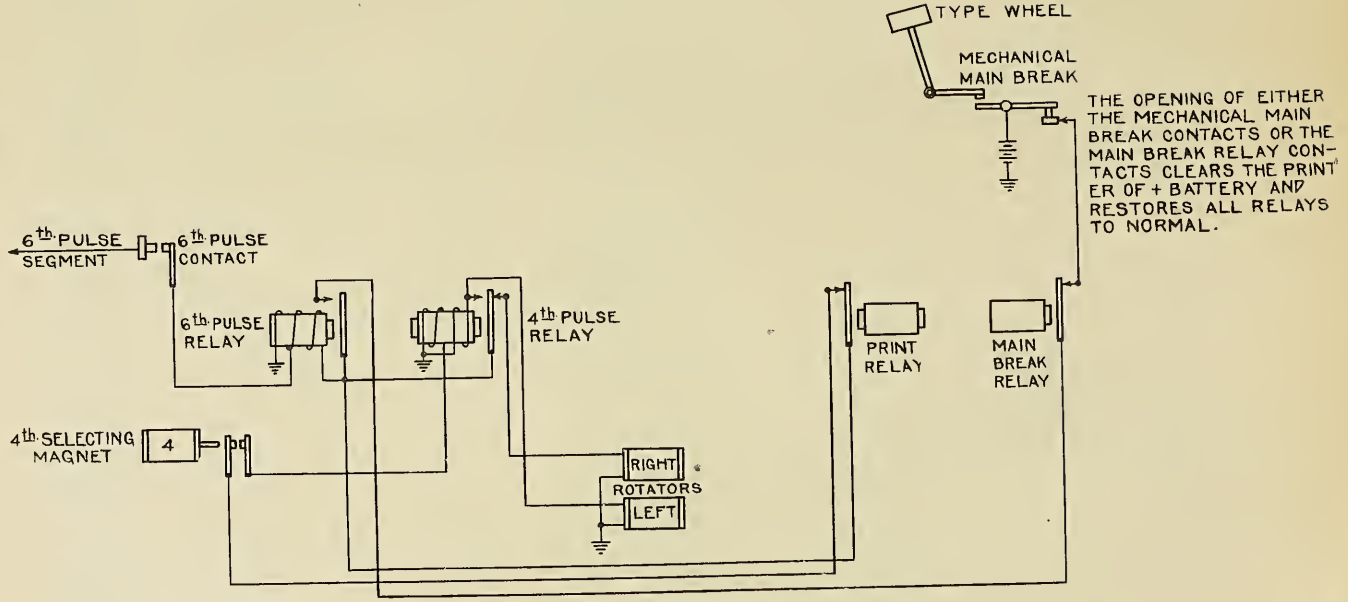

TYPE WHEEL
MECHANICAL MAIN BREAK
THE OPENING OF EITHER THE MECHANICAL MAIN BREAK CONTACTS OR THE MAIN BREAK RELAY CONTACTS CLEARS THE PRINTER OF + BATTERY AND RESTORES ALL RELAYS TO NORMAL.
6th PULSE SEGMENT
6th PULSE CONTACT
6th PULSE RELAY
4th PULSE RELAY
PRINT RELAY
MAIN BREAK RELAY
4th SELECTING MAGNET
4
RIGHT
ROTATORS
LEFT
THE 4th PULSE RELAY CONTACTS DETERMINE WHICH ROTATOR MAGNET (RIGHT OR LEFT) WILL BE OPERATED.
OPERATION OF PRINT RELAY CUTS OFF BATTERY TO 4th PULSE CONTACTS WHEN PRINTER IS READY TO STRIKE.

Fig. 8

thus determines which way the rotator shaft will move. However, the rotator magnets thus energized cannot rotate the rotator shaft because it is held in a locked position until the selector drum has completed its travel, unlocking it and permitting rotation.

15. The plungers of the two pairs of magnets, one above, the other below, the rotator shaft, press against the rotator shaft lever which is pinned to the shaft at the left end. As only one pair of these magnets is energized at a time the pressure of one of these plunger rods rotates the shaft either clockwise or counter-clockwise, depending upon which pair of magnets is energized. This motion is transferred from a gear segment pinned at the right end of this shaft to a pinion on a square shaft called the gear shaft. This shaft carries a sliding bevel gear which meshes with a horizontal bevel gear on the lower end of the typewheel shaft. Thus the typewheel will be rotated either to the right or to the left, depending upon which pair of rotator magnets is energized.

16. In order to stop the typewheel rotation at the proper position for any selected character an index arm is fastened at the end of the gear shaft in such a position that it is rotated by this shaft across the face of the left selector plate. Thus a stop pin projecting through the plates in the path of the index arm will arrest its rotation and consequently that of the typewheel (Fig. 10). As there is a stop pin in the drum for each letter or character on the typewheel, with the exception of the letters "J" and "Z," the letter corresponding to the stop pin against which the index arm is stopped will be in the printing position.

17. The rotary motion of the horizontal bevel gear is transferred through a universal joint to the typewheel shaft which is hollow and contains a spindle to which the typewheel is fastened by a spring clip. This spring clip passes through a slot in the upper part of the brass bushing of the typewheel and enters a groove in the spindle. A locating arm fastened to the hollow shaft passes through a square hole in the typewheel, thus causing the latter to rotate with the shaft (Fig. 11). The spindle is positioned by a collar and screw, and by means of a mechanism meshed with this collar and screw the spindle and thus the typewheel can be shifted upward from its normal position, thereby bringing into printing position a second row of characters on the typewheel. These characters are figures and punctuation marks. The operation of the shift mechanism which controls the up and down motion of the typewheel will be explained later.

18. The notched typewheel centering wheel (Fig. 12) is rigidly attached to the top of the hollow typewheel shaft and has a notch corresponding to each letter. The centering lever is pivoted at the point S and has projecting from its side, near the lower end a pin which travels in a cam slot cut in an upright piece fastened to the carriage. The forward movement of the striker causes the centering lever to enter a notch in the centering wheel and thus center the letter being printed.

19. As stated previously, upon the operation of the selector drum the reset magnet is energized, which not only resets the trip rods, but allows the reset contacts to close. These receive battery from the tongue of the sixth pulse relay and connect it with the print relay coil, thus operating it. When the left hand tongue of the print relay leaves its back contact it cuts off the battery from the reset magnet and the fourth pulse contacts. When the left hand tongue touches its front contact it connects battery to the striker and spacer magnets in series. This current to the striker magnet passes through the left hand tongue and back contact of the cut-out relay. The print relay also establishes a locking circuit through its right hand tongue which holds the relay operated until printing is completed.

20. Having the typewheel rotated to its proper printing position and centered for some character, the next operation is the striking, or actual printing. This operation is performed by the striker magnet and mechanism. The magnet is located at the extreme left end of the printer. Its plunger is fastened through a lever and adjustable link to the striker shaft lever C which is firmly attached to a horizontal square shaft called the striker shaft. Thus when the magnet is energized the striker is rotated clockwise.

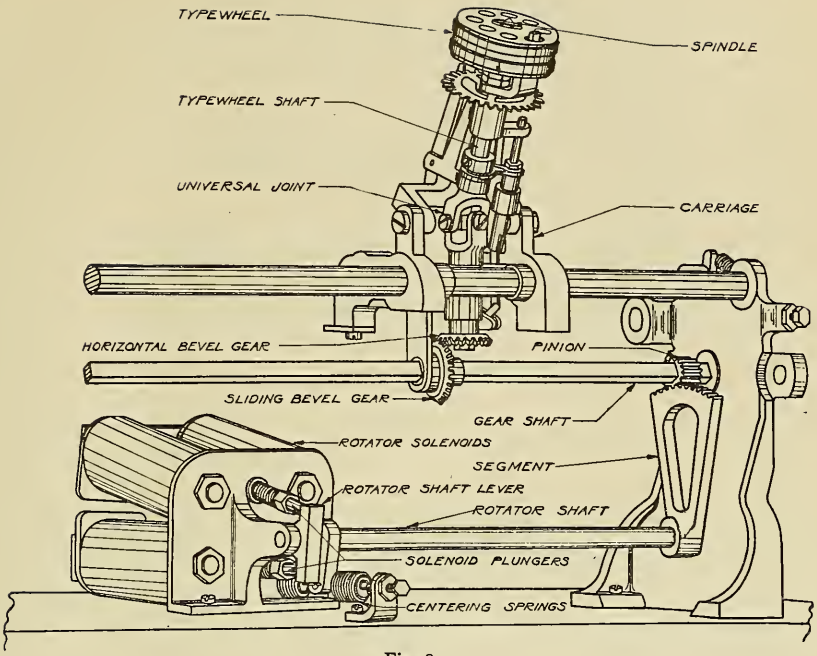

TYPEWHEEL
SPINDLE
TYPEWHEEL SHAFT
UNIVERSAL JOINT
CARRIAGE
HORIZONTAL BEVEL GEAR
PINION
SLIDING BEVEL GEAR
GEAR SHAFT
ROTATOR SOLENOIDS
SEGMENT
ROTATOR SHAFT LEVER
ROTATOR SHAFT
SOLENOID PLUNGERS
CENTERING SPRINGS

Fig. 9

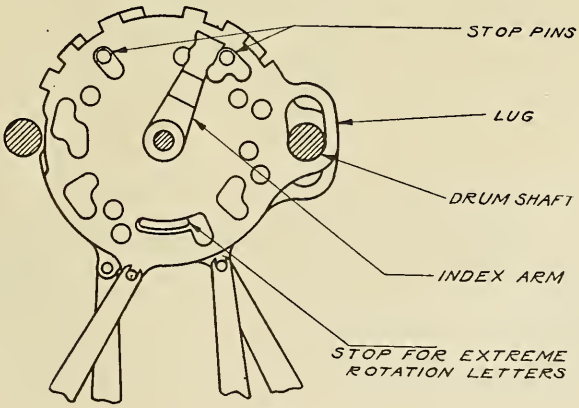

STOP PINS
LUG
DRUM SHAFT
INDEX ARM
STOP FOR EXTREME
ROTATION LETTERS

Fig. 10

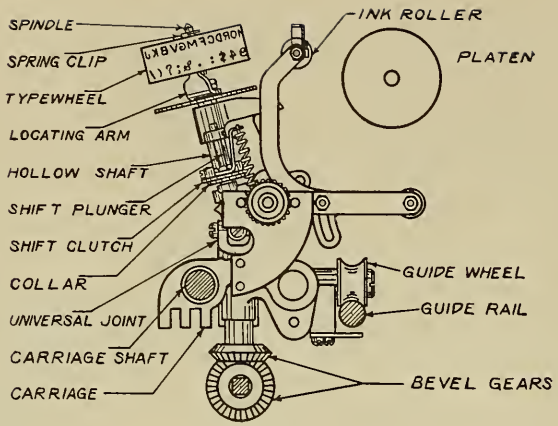



Fig. 11

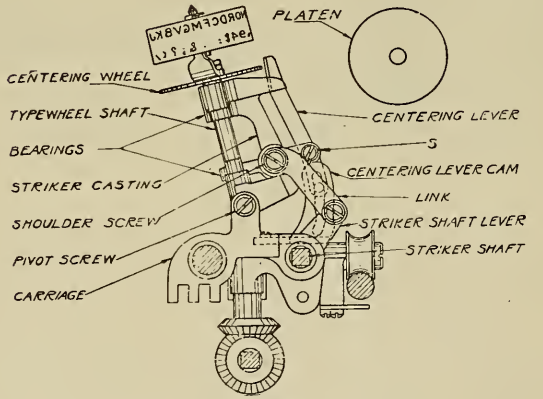



Fig. 12

This motion is transferred through the striker shaft lever and link to the striker casting (Fig. 12). This casting is pivoted upon two screws passing through lugs on either side of the carriage casting and has two bearings through which the typewheel shaft rotates.

**21.** The projecting end of lever C (Fig. 13) moves downward when the magnet operates and strikes the screw of the mechanical main break armature just before the typewheel hits the platen. The operation of this armature opens the mechanical main break contacts which act as a common return for all relays. This action restores to their normal unoperated position all relays previously locked up (Fig. 14).

**22.** Mounted below the carriage shaft and parallel to it are two racks or notched bars. Pivoted to the carriage casting are two pawls, the holding pawl and the spacer

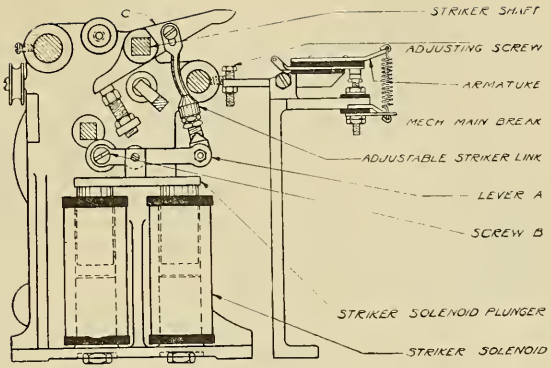



Fig. 13

pawl, which are held by springs against the faces of the two racks. One of the racks is stationary but the other rack can be moved to the right or left within certain limits by means of the spacer lever (Fig. 15).

**23.** At the same time the striker magnet is energized, current is flowing through the spacer magnet, thus keeping it energized. In this position its plunger is pushed against the spacer lever and has moved the rack to which this lever is connected to the left. This movement is just sufficient for the spacer pawl to be lifted out of one notch of the movable rack and dropped into the next notch. When the mechanical main break contacts open, the current to the spacer magnet is cut off and the spacer spring acting against the spacer lever causes the rack to move to the right. This movement advances the typewheel carriage the space of one letter after the letter has been printed. When it has moved this distance, the holding pawl drops into the next notch of the stationary rack and prevents the carriage from dropping back when the movable rack is again actuated by the spacer magnet.

**24.** The typewheel is returned to its normal position after rotation by the centering mechanism. A centering spring lever (Fig. 16) is fastened to the rotator shaft. Two opposed springs are connected to this lever so that if the typewheel is rotated, one of the springs will be contracted while the other will be extended. When the rotator magnet releases, the spring which has been extended will pull the spring lever back to a vertical position. Since the gear shaft, which carries the index arm and determines the typewheel position, is controlled by the rotator shaft through the gear segment and pinion, the index arm and typewheel will thereby be brought back to their normal positions.

**25.** To more accurately determine the vertical position of the index arm an auxiliary means is provided which acts only when the index arm is nearly in its vertical position. On the gear shaft between the right end bearing and the index arm is a centering cam. Two centering pawls (Fig. 16) are held by the centering pawl spring in such a position that if the index arm rotates to the right the projection of the centering cam which moves with it will raise the end of the left hand centering pawl, thereby stretching the spring. This spring exerts a force to bring the index arm back to its vertical position when the index arm is released. If the index arm rotates to the left, the right hand centering pawl acts in a similar manner. If the index arm rotates very far, the centering pawl will slip over the extension of the cam and slide on the smooth surface and have no effect on the index arm until it again approaches its vertical position.

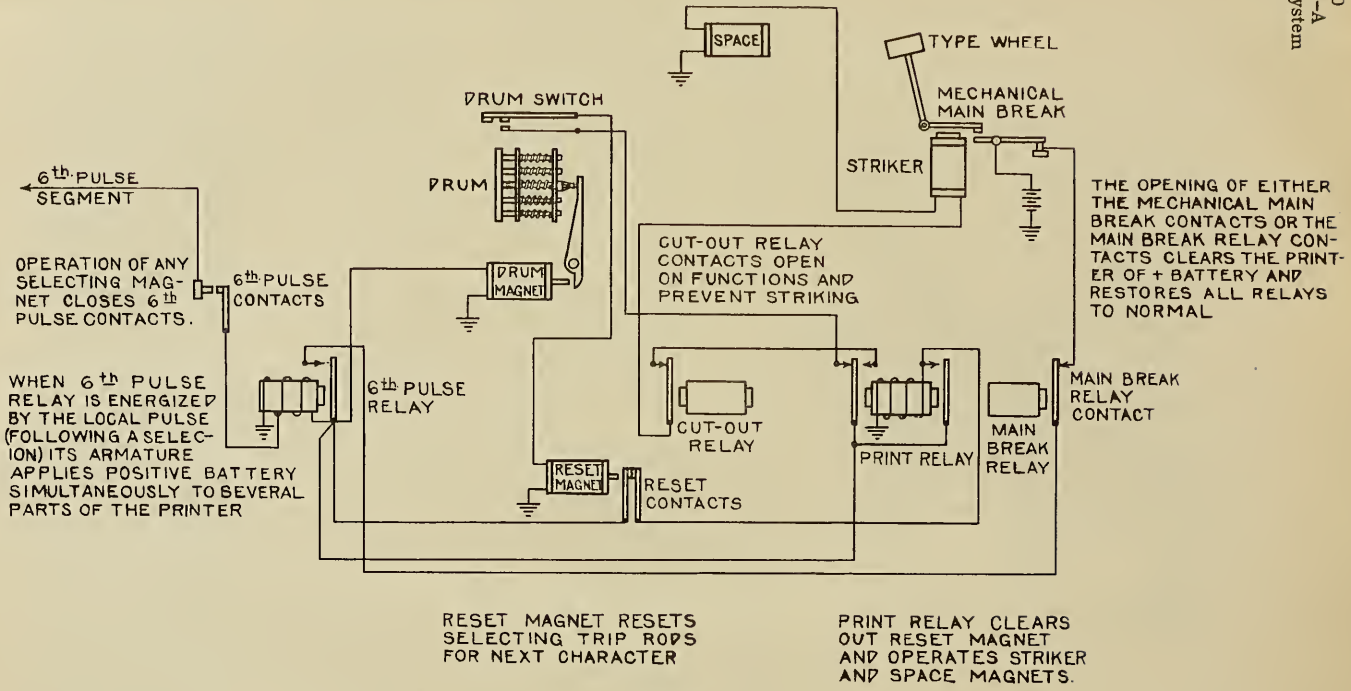

SPACE
TYPE WHEEL
MECHANICAL MAIN BREAK
DRUM SWITCH
DRUM
STRIKER
6th PULSE SEGMENT
THE OPENING OF EITHER THE MECHANICAL MAIN BREAK CONTACTS OR THE MAIN BREAK RELAY CONTACTS CLEARS THE PRINTER OF + BATTERY AND RESTORES ALL RELAYS TO NORMAL
DRUM MAGNET
CUT-OUT RELAY CONTACTS OPEN ON FUNCTIONS AND PREVENT STRIKING
OPERATION OF ANY SELECTING MAGNET CLOSES 6th PULSE CONTACTS.
6th PULSE CONTACTS
WHEN 6th PULSE RELAY IS ENERGIZED BY THE LOCAL PULSE (FOLLOWING A SELECTION) ITS ARMATURE APPLIES POSITIVE BATTERY SIMULTANEOUSLY TO SEVERAL PARTS OF THE PRINTER
6th PULSE RELAY
CUT-OUT RELAY
PRINT RELAY
MAIN BREAK RELAY
MAIN BREAK RELAY CONTACT
RESET MAGNET
RESET CONTACTS
RESET MAGNET RESETS SELECTING TRIP RODS FOR NEXT CHARACTER
PRINT RELAY CLEARS OUT RESET MAGNET AND OPERATES STRIKER AND SPACE MAGNETS.

Fig. 14

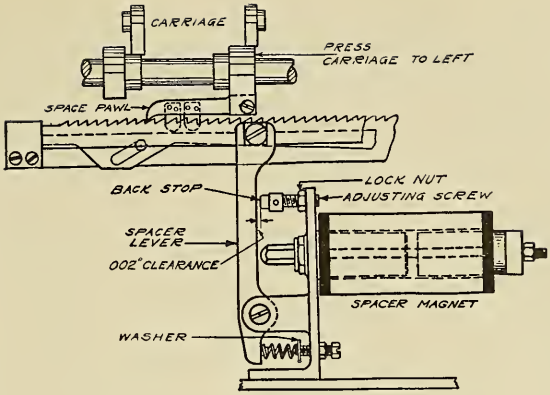



Fig. 15

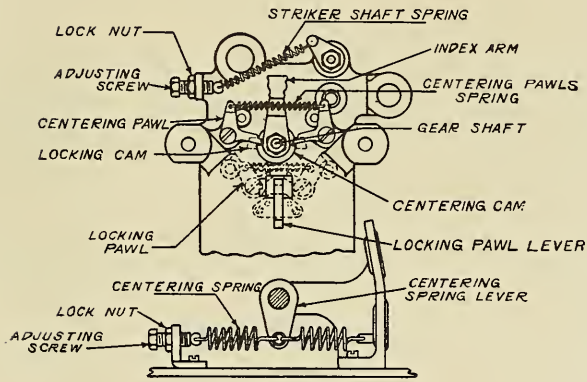



Fig. 16

26. The index arm is normally locked in its vertical position by means of the locking cam and the locking pawls. The locking cam is fitted on the gear shaft at the inner side of the right end bearing. The locking pawls are pivoted below the gear shaft and held by a spring in such a manner that if the gear shaft tends to rotate, the lugs of the locking cam striking the vertical extensions of the locking pawls will prevent the rotation.

27. These locking pawls must be thrown out of engagement with the locking cam before the typewheel can be rotated to print any letter. Referring to Figure 6 it will be seen that a ram is attached to the lower part of the left hand drum plate. When the drum is operated this ram strikes the lock pawl lever, one end of which projects through the right end bearing. As the ram pushes against the right end of this lever, its left end moves upward and, striking the locking pawls, moves them into the positions shown dotted in Figure 16. This leaves the gear shaft free to rotate in either direction.

28. Had the particular setting of the selecting magnets corresponded to a function such as carriage return, line feed, etc., instead of a character, the operation of the printer

would be as follows: The sixth pulse relay would operate and connect battery as before to the drum magnet. Pressing against the edge of the left hand plate of the selector drum are seven levers, each controlling a contact as shown in Figure 17. The center one of these levers controls the drum switch, which is permitted to close every time the selector drum operates. The functions performed by this switch have already been described. The six other levers are function levers. When the selector drum moves forward, these levers drop onto the periphery of the interference plates (Fig. 6) and, depending on what function has been selected, the notches in the plates will be lined up opposite one of the function levers which will drop into the notches and the corresponding contact will close.

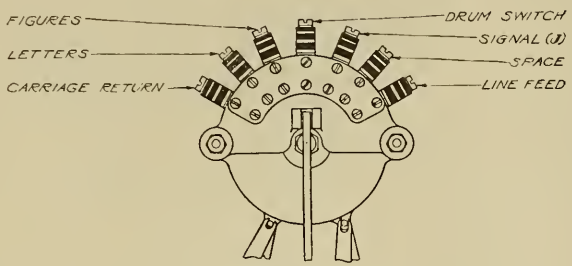



Fig. 17

29. If for instance the line feed function had been selected, the notches would be lined up under this lever and when the drum moved forward this lever would fall into the slot thus formed, thereby permitting the line feed contact to close. Battery would then flow from the left hand tongue of the fourth pulse relay, through its back contact, the left hand winding of the cut-out relay, the closed line feed function contacts to the line feed magnet, thereby operating this magnet (Fig. 18).

30. The battery to the line feed magnet, passing through the cut-out relay, would operate this relay and battery from its right hand tongue would flow through its front contact to the main break relay. The operation of the main break relay would cut off all battery to the relays and magnets of the printer, restoring them to normal.

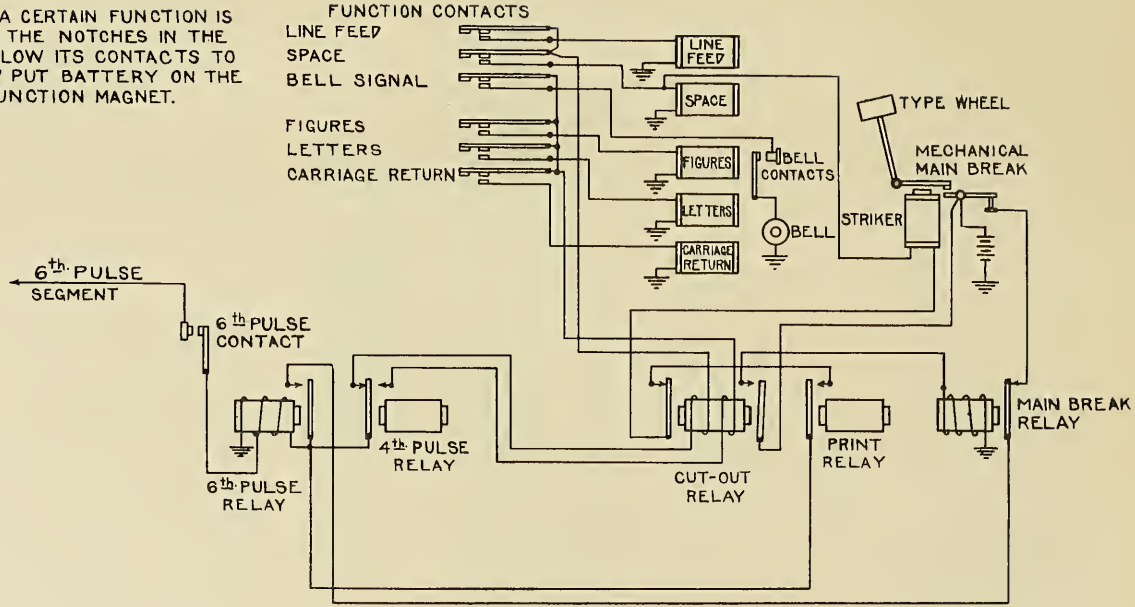
31. As the drum came forward the locking pawls were operated and the typewheel rotated in the usual way. When the print relay was operated by the closing of the reset contacts the striker and spacer magnet were not operated, however, because the operation of the cut-out relay opened the circuit from the left hand front contact of the print relay through the left hand tongue and back contact of the cut-out relay to the striker and spacing magnets.

32. Between the two racks (Fig. 19) is mounted a bar, which is moved upward when the carriage return solenoid is operated. When this bar moves upward it strikes two projecting lugs, one on each of the pawls attached to the carriage, lifting these pawls out of the notches of their respective racks and freeing the carriage.

33. A cord attached to the left side of the carriage casting passes over two pulleys and around a spring barrel at the left hand end of the printer. When the carriage pawls are released the tension of the spring in the carriage return barrel quickly winds up the cord and thus draws the carriage back to the left hand end of the line.

34. To hold the pawls off the rack until the carriage has fully returned, a locking pawl is attached to the movable spacer rack. When the carriage return bar is lifted by the carriage return solenoid a projecting stud in this bar slips into a notch in the pawl, holding the bar in its extreme upper position and the carriage pawls off the racks.

WHEN A CERTAIN FUNCTION IS SELECTED THE NOTCHES IN THE PLATES ALLOW ITS CONTACTS TO CLOSE AND PUT BATTERY ON THE PROPER FUNCTION MAGNET.




4th PULSE RELAY DETERMINES WHETHER + BATTERY SHALL BE PLACED ON CONTACTS OF FUNCTIONS CONTAINING 4th PULSE OR THOSE NOT CONTAINING THE 4th PULSE.

CUT-OUT RELAY OPERATES SIMULTANEOUSLY WITH THE FUNCTION. WHEN OPERATED IT PREVENTS STRIKING BY OPENING THE PRINT RELAY ARMATURE CIRCUIT AND ESTABLISHES A CIRCUIT THROUGH THE MAIN BREAK RELAY WHICH CLEARS OUT THE PRINTER.

Fig. 18

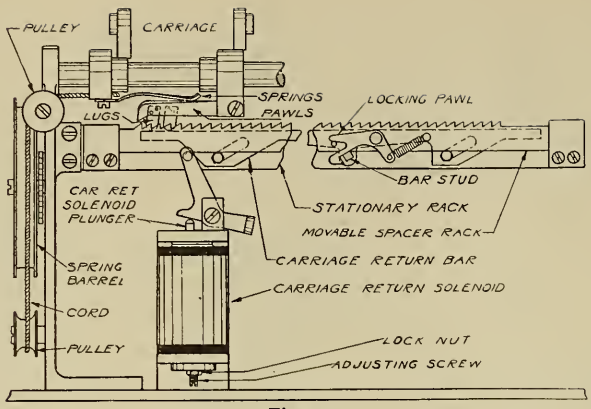



Fig. 19

35. When the first letter of a new line is printed the spacer magnet operates, moving the spacer rack to the left. This movement of the rack also moves the locking pawl to the left and allows the stud in the carriage return bar to disengage. The carriage return bar drops, and the two pawls attached to the carriage casting again engage the racks and perform the spacing function.

36. An air buffer shown in Figure 20 is provided to absorb the momentum of the carriage as it returns to the beginning of the line. When the carriage is a short distance from the carriage stop it strikes the buffer lever, forcing the piston into the cylinder against the pressure of the air, which escapes through the small adjustable outlet. Thus the carriage is prevented from slamming against the carriage stop.

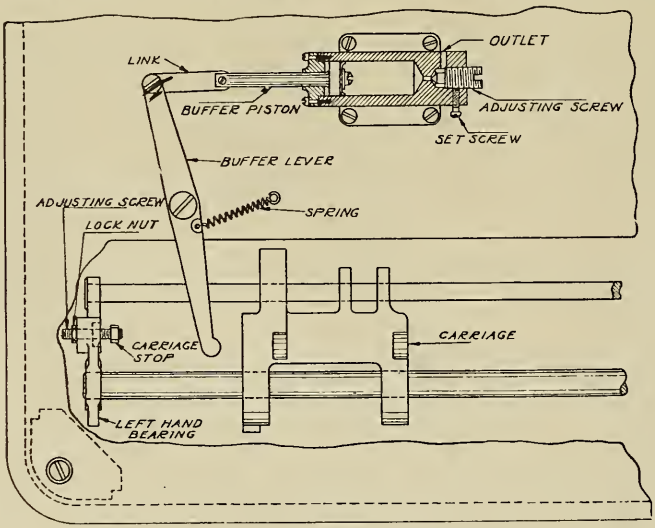



Fig. 20

37. The line feed mechanism feeds up the paper when a new line is to be started. A ratchet wheel is attached to the left hand end of the platen roll. Attached to a short shaft passing through the platen bracket is a line feed lever, near the upper end of which is pivoted a pawl. The line feed magnet is located on the under side of the printer top casting. A plunger rod which is screwed into the magnet yoke passes through the top casting and when the yoke is pulled upward, through the magnet being energized, the plunger rod presses against a short lever A (Fig. 21) on the same shaft to which the line feed pawl lever is attached. This forces the line feed pawl against the ratchet, revolving the latter and feeding up the paper. A detent is pressed against the teeth of the ratchet by a spring to insure even spacing.

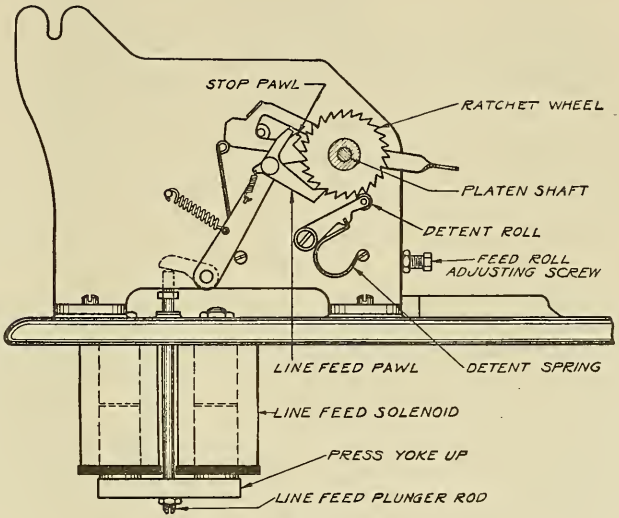



Fig. 21

38. Mounted loosely on the platen shaft is a lever to regulate the position of the line feed pawl. When the outer end of this lever is up it fixes the position of the pawl so that when the magnet operates, the platen will rotate the distance of only one tooth of the ratchet. When the lever is down, the pawl moves the platen ratchet two teeth.

39. As before mentioned, the typewheel is attached to a spindle which fits into a hollow portion of the typewheel shaft. This spindle is held in position by means of a collar and a screw. There is a slot in the hollow shaft through which the screw passes and thus, by moving the collar up and down, the spindle carrying the typewheel may be raised or lowered.

40. Fitting into a groove in this collar is a fork shaped shift clutch. This clutch is fastened by a nut to the shift plunger which passes through a bearing in the striker casting. The lower end of this plunger is attached by means of a link to a pivoted lever L fastened to the under side of the carriage. On the lower end of this lever is a roller which bears against a shift bar G pivoted in the right and left hand bearings which carry the shafts. Figure 22 shows this mechanism as seen from the back of the printer.

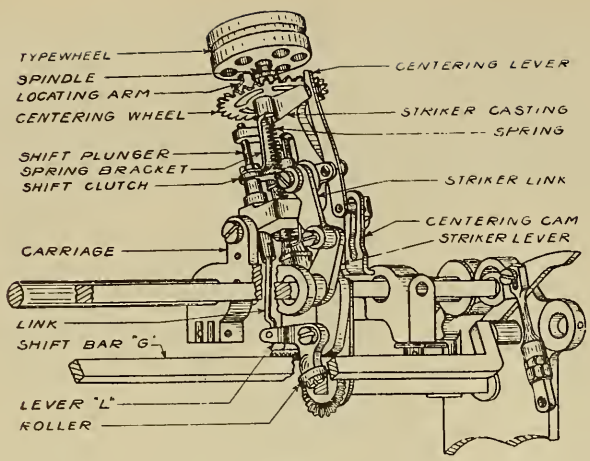



Fig. 22

41. Near the right end of the printer and to the rear are mounted the figures and letters magnets (Fig. 23). When the figures magnet operates, its plunger presses against the shift lever, in the upper end of which is the shift lever adjusting screw. The position of the adjusting screw is such that when the lever is pushed outward by the action of the figures magnet the screw presses against the shift bar G, thereby rotating it. The rotation of the bar G moves to the lever L (Fig. 22), the roller of which bears against the bar, outward toward the front of the printer. The other end of this lever is attached, by means of the link, to the shift plunger which carries the shift clutch fitting in the groove of the shift collar. Due to the form of the lever L the outward movement of the roller causes the shift plunger to move upward. This upward movement is transmitted through the clutch to the collar and thus to the typewheel spindle, raising the typewheel until the lower row of figures and characters is in the printing position.

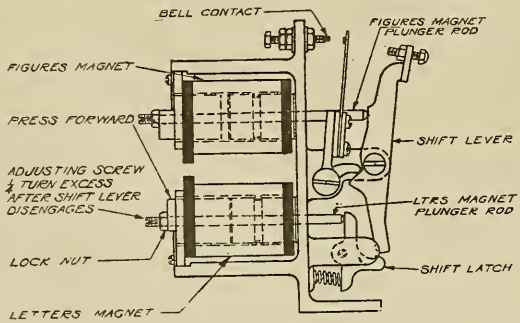



Fig. 23

42. The typewheel is held in its shifted position after the figures magnet has operated. The lever against which the figures magnet plunger presses when the magnet operates is pivoted approximately in its center. The lower end of the lever rests against a shift latch. A spring pressing against the lower end tends to move the projecting end of the latch upward. Thus when the figures magnet operates, the lower end of the shift lever will pass over the rounded end of the latch. The latch spring will move the latch upward and catch the lever and thus hold the typewheel in shifted position.

43. When it is desired to unshift or release the typewheel from its shifted position, the letters magnet is operated through the letters contact. The plunger of this magnet, when the magnet is operated, presses against the upper end of the shift latch, pushing it outward and disengaging the shift lever. A spring attached to a bracket on the shift plunger (Fig. 22) then pulls down the typewheel.

44. For signalling purposes a bell is provided on the printer. This bell is operated once whenever the characters FIGS, J, LTRS are successively sent to the printer. The circuit to the bell passes through the signal function contacts. These contacts are closed whenever the combination representing the letter "J" is received. The circuit from the signal function contacts leads to a contact spring fastened to a short lever E (Fig. 23). This lever E presses against the shift lever in such a manner that when the lever has been moved to its operated position by the figures magnet the contact spring will press against the screw, thus closing the circuit. When a figure signal is received and followed by the signal for the letter "J," battery will flow through the signal function contacts and to the contacts closed by the figures magnet to the bell, thereby ringing the bell. When the shift lever is restored to its normal (Letters) position, the contact spring will be drawn away from the contact and the circuit opened.

45. As an indicator to guard against the loss of messages through signals being received when the printer is in a "tied-up" condition, due to the failure of a relay to operate or an open circuit, a lamp known as the "tie-up" lamp is provided. This lamp should flash while the printer is operating and should not flash while the printer is not operating. Therefore if the lamp flashes and the printer does not operate, it is an indication that the printer is "tied-up."

46. As shown in Figure 7 the unused segments of the receiving commutator are connected together and to the "tie-up" lamp in the printer. As the receiving brushes pass over these segments the lamp will receive current when the relay armature is against its marking contact and will receive no current when the relay armature is against its spacing contact. Thus when signals are being received which should operate the receiving printer the lamp will flash. When no marking signals are being sent over the line the lamp will not be affected.

47. **Sequence of Operations.** By referring to Figure 7 the sequence in which the various relays and magnets operate may be traced. The order in which the operations involved in printing a letter take place is as follows:

(a) **Selection.** A setting of certain interference plates by the operation of the corresponding selecting magnets. Their operation also closes the sixth pulse contacts.

(b) **Sixth Pulse.** Operation of the sixth pulse relay which locks itself in and supplies current to the fourth pulse contacts. If these contacts have been closed the fourth pulse relay operates.

(c) **Drum Magnet.** The drum magnet receives current at the same time as the fourth pulse relay, but the relay, being faster than the magnet, completes its operation first.

(d) **Reset Magnet.** When the selector drum has moved a short distance the drum switch closes and connects battery to the reset magnet.

(e) **Rotation.** When the selector drum completes its travel it unlocks the rotating mechanism and one of the rotator magnets which has been receiving current from the fourth pulse relay rotates the typewheel.

(f) **Striking.** As the reset magnet completes its travel it closes the reset contacts which connect battery to the print relay. The operation of the print relay disconnects battery from the fourth pulse contacts and the reset magnet and connects battery to the striker and spacer magnets in series.

(g) **Restoring.** When the typewheel strikes the platen the lever attached to the striker shaft opens the main break contacts, thereby restoring all operated relays and magnets to their normal positions.

(h) **Functions.** In case a function is selected, such as line feed or carriage return, the succession of operations is the same except that when the selector drum has nearly completed its travel the selected function contact will close and connect battery through one winding of the cut-out relay to the corresponding function magnet. The operation of the cut-out relay will open the circuit from the print relay to the striker magnet and connect battery to the main break relay. This will prevent the typewheel from striking and restore the printer by opening the main break relay contacts (Fig. 18).

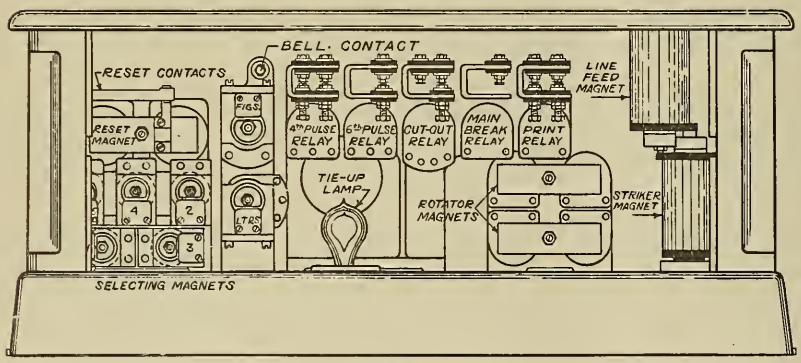



Fig. 24

48. The operations performed by the relays employed in the printer may be summarized as follows:

(a) **Sixth Pulse Relay.** The front contact of this relay is connected to battery through the main breaks. To its tongue are connected the drum magnet, reset contacts and the tongues of the fourth pulse and print relays. Thus the sixth pulse relay must first operate to supply current to these and initiate the operation of the printer. This relay has two windings. It is operated through one winding and locks itself with a weaker current through both windings in series.

(b) **Fourth Pulse Relay.** This relay, through its left hand tongue and contacts, determines which set of function contacts shall receive current. Through its right hand tongue and contacts it determines which rotator magnet shall be operated. This relay has two windings. It is operated through one winding and locks itself with a weaker current through the second winding.

(c) **Print Relay.** When its left hand tongue leaves the back contact it cuts off the battery to the reset magnet and the fourth pulse contacts. When this tongue touches its front contact it supplies battery to the striker and spacer magnets. The right hand tongue and front contact control the locking circuit of the relay.

(d) **Cut-out Relay.** The left hand tongue and contact control the striker circuit, preventing the printer from striking on functions. The right hand tongue supplies current through the front contact to operate the main break relay and restore the printer after function operation.

(e) **Main Break Relay.** This relay operates only on functions to cut off the battery to all relays and magnets and restore them to normal.

(f) It should be noted that the operation of the fourth selecting magnet does not cause the operation of the fourth pulse relay immediately, but merely closes contacts which complete a circuit from the tongue of the sixth pulse relay to the magnet of the fourth pulse relay. The circuit passes through the left hand tongue and back contact of the print relay. Therefore the fourth pulse relay can operate only after the sixth pulse relay operates and before the print relay operates. This prevents the fourth pulse relay from operating during the printing of a letter. Both tongues of the fourth pulse relay are connected to the tongue of the sixth pulse relay and receive battery whenever the sixth pulse relay operates. If the fourth pulse relay has been operated, due to the fourth interval of the signal being marking, this battery will flow through the front contacts to the left rotator and to the function contacts corresponding to carriage return, letters, figures and signal. If the fourth pulse relay is not operated, the battery from its tongues flows through the back contacts to the right rotator magnet and the function contacts corresponding to space and line feed. Of course the path it takes after reaching the function contacts is determined by the setting of the interference plates of the drum, which determines which, if any, of the function contacts shall close.

## ADJUSTMENTS

1. **General.** Before adjusting the printer, this unit shall be thoroughly cleaned and examined for mechanical or electrical defects. A thin film of oil shall be applied to all bearing surfaces.

2. In order to properly clean and inspect the printer the top must be removed. This is done by first removing the inker lever bracket from the inker plate and then taking out the four screws which hold the top to the corner posts.

3. **Relays.** The contact points of the relays are made of tungsten and require very little attention. When necessary a burnisher shall be passed between the relay contacts to dislodge any dirt which has accumulated. If the contacts of the relay tongues become pitted they shall be smoothed with a fine carborundum stone.

4. **Relay Tongue Travel.** First back off the contact screws. If the relay has more than one contact tongue, move the armature slowly until the contact tongues leave the back contacts and note if all the tongues leave the back contacts at exactly the same time. If they do not they shall be bent until they line up properly.

5. After lining up the tongues the travel shall be adjusted so that when the armature is held against the pole piece the gap between the tongue and the back contact is .020 inch (use gauge). Figure 25 shows the method of measuring this gap. The amount of the gap can be regulated by loosening the screw which holds the pole piece and sliding the pole piece one way or the other until the proper gap is obtained, when the screw shall be again tightened.

6. **Armature Spring Tension.** After the relay contact tongues have been lined up and the tongue travel adjusted, the tension of the armature return spring shall be checked. This is done by means of a spring balance as shown in Figure 26. The reading shall be taken just as the contact tongue leaves the back contact. The tension of the armature return spring is regulated by means of the spring adjusting screw. Loosen the lock nut and turn the screw clockwise to decrease the tension and counter-clockwise to increase the tension. Be sure to tighten the lock nut after each change of adjustment.

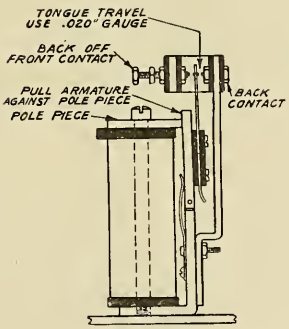



Fig. 25

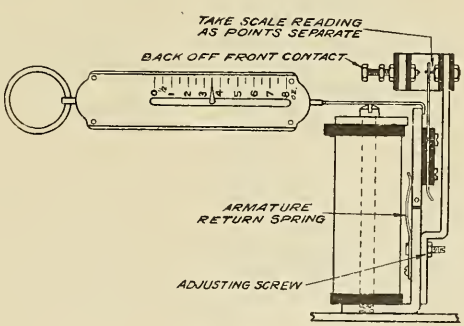



Fig. 26

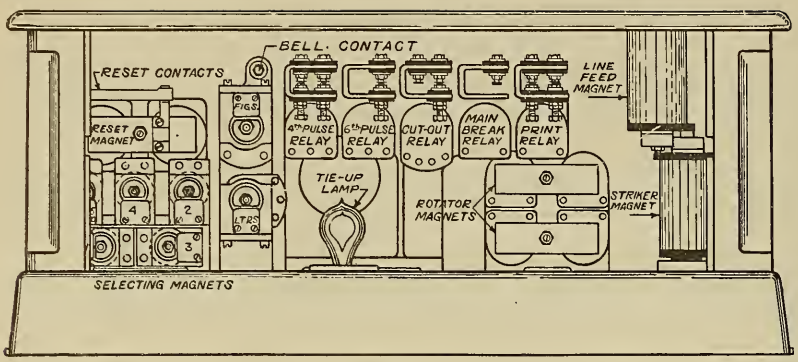



Fig. 24

7. The values of the spring tensions of the various relays, the locations of which are shown in Figure 24, are as follows:

| | |
|---|---|
| Fourth pulse relay | 3½ ounces |
| Sixth pulse relay | 2½ ounces |
| Cut-out relay | 3½ ounces |
| Main break relay | 5½ ounces |
| Print relay | 3½ ounces |

8. **Relay Contact Gap.** With the relay in its normal position, the front contact screws shall be turned in until they come within .004 inch of the contact tongue. After the lock nut is tightened the .004 inch gauge shall pass through the space between the contact screw and tongue without any clearance.

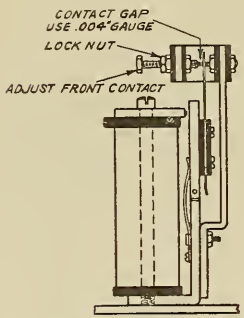



Fig. 27

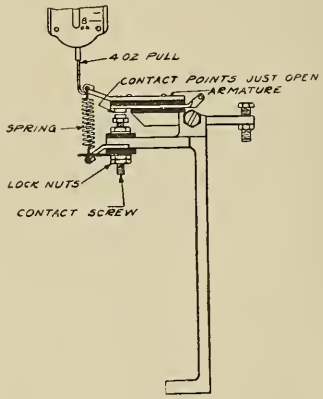



Fig. 28

9. **Main Break Contact Adjustment.** The main break contact screw (Fig. 28) shall be so adjusted that a pull of four ounces at the extreme end of the main break armature will just open the contact points.

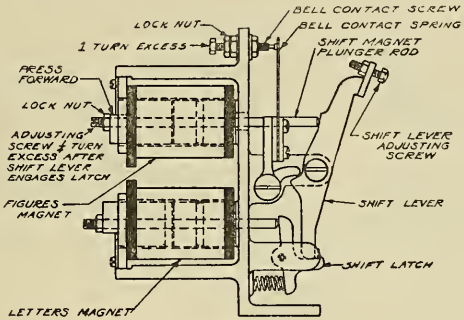



Fig. 29

10. **Figures Magnet Plunger Travel.** The travel shall be adjusted so that the lower end of the shift lever passes over the end of the shift latch with a slight amount of over-travel to insure the latch catching the lever and holding the typewheel in the shifted position (Fig. 29). To regulate this travel, loosen the lock nut of the shift magnet plunger adjusting screw and back off the plunger rod until it does not move the shift lever far enough for it to be engaged by the shift latch when the plunger is pressed into the magnet. Now advance the plunger rod slightly by turning in the adjusting screw and press the magnet plunger into the magnet again. Keep advancing the plunger rod slightly until the shift lever is just engaged by the shift latch and the typewheel held in the shifted position. Advance the plunger rod one-quarter turn more and tighten the lock nut.

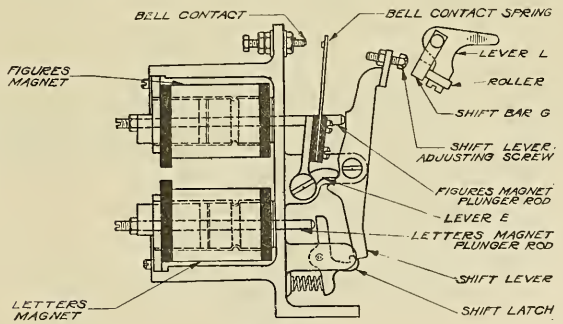



Fig. 30

11. **Letters Magnet Plunger Travel.** The travel of the letters magnet plunger should be sufficient to disengage the shift latch from the shift lever and release the typewheel from the shifted position (Fig. 30). The method of making the adjustment is similar to the figures magnet adjustment. With the typewheel in its shifted position, back off the letters magnet plunger rod, press the plunger back into the magnet and then advance the plunger rod gradually until it just disengages the shift latch from the shift lever and releases the typewheel. Give the adjusting screw one-quarter turn excess and tighten the lock nut.

12. **Signal Bell Contacts.** With the typewheel in the shifted position, loosen the lock nut of the bell contact screw and adjust the screw until it just touches the contact spring (Fig. 29). Give it one full turn excess and tighten the lock nut.

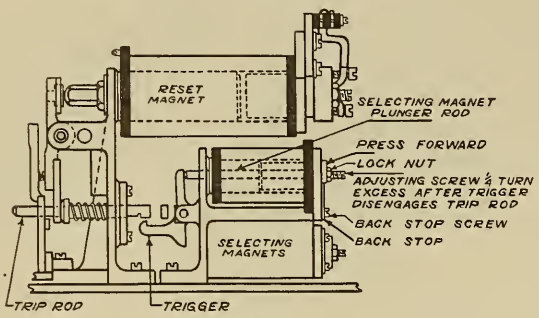



Fig. 31

13. **Selecting Magnet Plunger Travel.** The travel of each selecting magnet plunger shall be sufficient to disengage its trigger from the trip rod plus a slight amount of over-travel. Turn the adjusting screw, Figure 31, until the trip rod is not tripped when the plunger is pressed into the magnet. Advance the adjusting screw until the trigger is just disengaged from the trip rod; give it not more than one-quarter turn additional and tighten the lock nut.

14. When the trip rods are all reset, pull each selecting magnet plunger against its back stop and note if there is a slight amount of clearance between the end of the plunger rod and the upper part of the trigger. If there be no clearance, bend the back stop slightly so that there is a gap of between .004 and .010 inch at this point. First make sure that the back stop screws are tight.

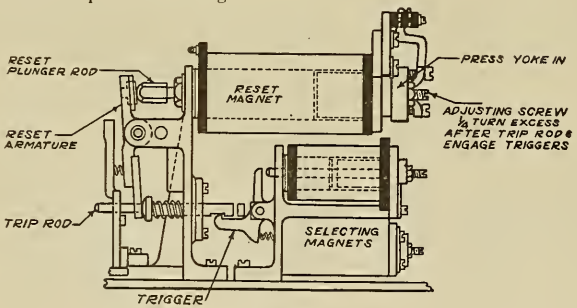



Fig. 32

15. **Reset Magnet Travel.** The reset magnet plunger shall travel just far enough to reset the trip rods into engagement with their triggers plus a slight additional travel. As there may be some variation in the travel of the five trip rods, they shall all be tripped and the travel of the reset plunger shall be adjusted until it is just sufficient to reset all the trip rods. The adjusting screw shall then be given one-quarter turn additional and the lock nut tightened (Fig. 32). In making this adjustment, the reset magnet plunger may be pressed into the magnet by hand, but care must be taken that the pressure is applied at the center of the yoke.

16. **Sixth Pulse Contacts.** The sixth pulse contact screw is mounted on the reset armature (Fig. 33) so that when any of the trip rods operate, and move the lower part of the armature forward, the sixth pulse contact screw will press against the sixth pulse contact spring. With none of the trip rods operated, there shall be .004 inch clearance between the sixth pulse contact screw and the contact spring. To prevent the sixth pulse contact from vibrating, it is backed up with a heavier spring. There shall be a space between these two springs so that the contact spring will not touch its back stop spring until the sixth pulse contact on the reset armature has completed its travel in the direction of the reset magnet. If these two springs are touching when the contacts are open, the operation of the trip rods will be retarded, due to the pressure of these two springs against the reset armature.

17. **Fourth Pulse Contacts.** The fourth pulse contacts shall be bent so that when the fourth pulse trip rod is in its unoperated position there is about 1/16 inch clearance between the inner contact spring and the end of the trip rod. At the same time there shall be a .010 inch gap between the two contacts. When the trip rod operates it should close the contacts and bend the springs slightly (Fig. 33).

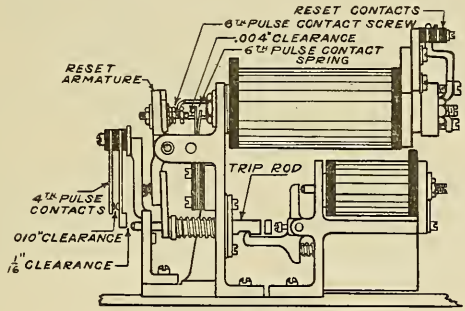



Fig. 33

18. **Reset Contacts** When the reset plunger is in its operated position there shall be about a .030 inch clearance between the fibre block and the adjustable bracket on the yoke. The contact pressure shall be two and one-half ounces measured on the fibre block of the rear contact spring (Fig. 34).

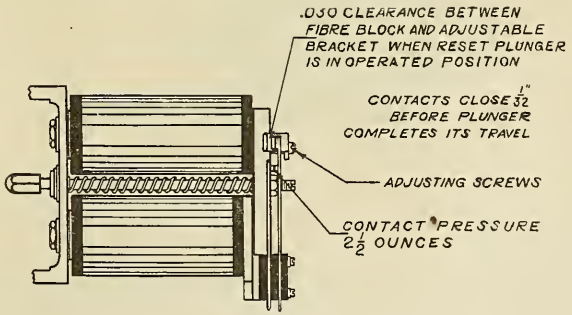

.030 CLEARANCE BETWEEN FIBRE BLOCK AND ADJUSTABLE BRACKET WHEN RESET PLUNGER IS IN OPERATED POSITION
CONTACTS CLOSE 1/32" BEFORE PLUNGER COMPLETES ITS TRAVEL
ADJUSTING SCREWS
CONTACT PRESSURE 2 1/2 OUNCES

Fig. 34

19. **Interference Plates.** When the trip rods are unoperated the adjusting screws in the shaft levers shall be regulated so that there is a .020 inch clearance between the end of each trip rod and the adjusting screw in the shaft lever (Fig. 35).

20. When this adjustment has been made, trip each of the rods and note that the interference plates make their full travel; that is, that the lower edge of the slot in the lug of each plate is against the drum shaft.

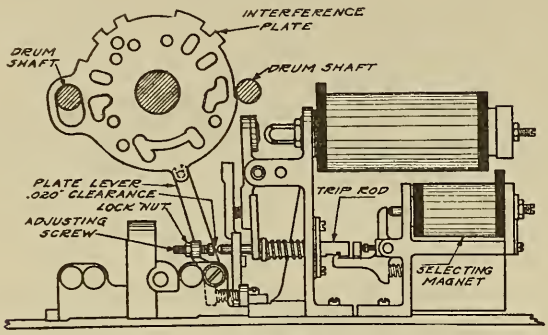



Fig. 35

21. **Drum Switch.** Figure 36 shows the drum switch mounted on the selector. The small casting, which carries the lever controlling the contacts, may be rocked by loosening one adjusting screw and tightening the other and thus the contact gap can be varied. Loosening the lower screw and tightening the upper one decreases the contact gap, while loosening the upper screw and tightening the lower one increases it. With the selector

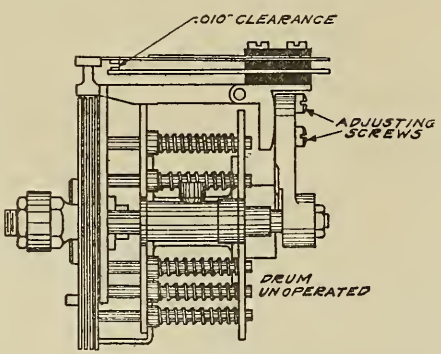



Fig. 36

drum in its unoperated position, the adjusting screws shall be regulated so that the drum switch contacts stand open .010 inch.

22. **Function Contacts.** The function contacts can be regulated in the same manner as the drum switch. When adjusting the function contacts, however, the first interference plate shall be operated and the selector drum held in the operated position. Under these conditions, all of the function contacts shall be adjusted to stand open

.010 inch (Fig. 37). The reason for operating the first plate is because when no interference plates are set the carriage return function contact will close when the drum is operated. With the drum in the operated position and a selection set up, the upper contact spring of the drum switch or any of the function contacts shall have such tension that an upward pull of two to two and one-half ounces measured at the free end of the upper spring is required to open the contacts. If it is necessary to bend a spring to secure the required tension the contact gap shall be readjusted.

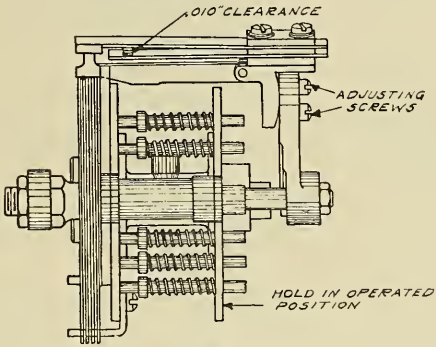



Fig. 37

23. **Striker Shaft Buffer.** Adjust the striker shaft buffer so that there is 1/8 inch clearance between the pin in the centering lever and the top of the cam slot. Hold the typewheel away from the platen when measuring this clearance (Fig. 38).

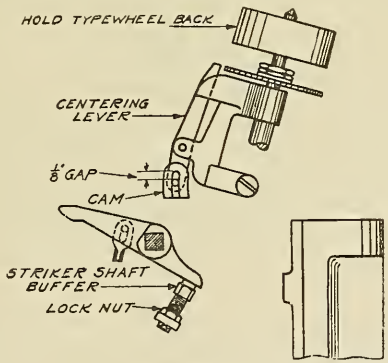



Fig. 38

24. **Striker Shaft Spring.** The tension of the striker shaft spring shall be regulated by means of the adjusting screw so that a pull of four ounces on the front of the centering wheel will be required to start to move the typewheel forward after the play in the bearings has been taken up. Figure 16 shows the striker shaft spring.

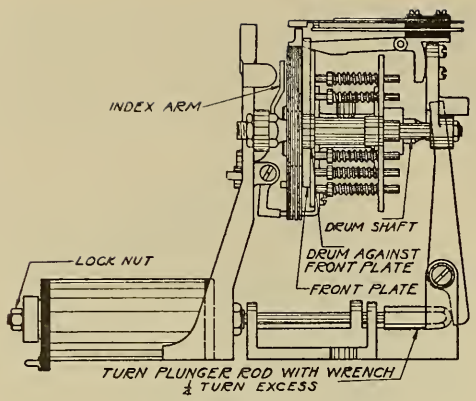



Fig. 39

25. **Drum Magnet.** To adjust the drum travel, put the printer on a set, turn on the power and hold the typewheel so that it cannot strike, then trip one of the selecting magnets. This will cause the drum magnet to operate. Loosen the lock nut and back off the plunger rod by turning it with a wrench until the selector drum does not make its full travel. Now turn the rod in the opposite direction, advancing the plunger rod until the drum is tight against the front plate (Fig. 39). It is best to try this several times, backing off the plunger rod and coming up slowly to the stopping point. When this point is determined give the rod a quarter turn excess and tighten the lock nut. If the drum travel is insufficient, the pins will not project far enough through the plates. If the plunger rod is turned more than a quarter turn excess after the drum has just completed its travel, however, the full strength of the magnet will not be utilized because the magnet plunger will be held away from the core when the drum has completed its travel. This will make the drum action slow.

26. **Typewheel Train.** Due to the nut holding the sliding bevel gear loosening, or if the gears were removed and not meshed in their exact relation to the rotator mechanism when assembling the unit again, the typewheel train may not be centered with respect to the rotator mechanism. If the blank portion of the typewheel between E and N is not facing the platen when the gear shaft is held stationary by the locking pawls, loosen the nut holding the sliding bevel gear and rotate the typewheel so that the blank portion (between E and N) is in the exact printing position and that there is equal play on either side of the centering lever relative to the centering wheel. Then tighten the nut. To check this adjustment unlock the locking pawls and rotate the gear shaft first to one extreme then to the other and see if the typewheel is stopped at its proper printing position for the letters "J" and "Z," with the same amount of play in the two positions.

27. **Rotator Magnets.** Figure 40 shows the adjustment of the rotator plungers. The travel of these plungers must be sufficient to rotate the typewheel to its two extreme positions, which correspond to the letters "J" and "Z." To adjust the rotator plunger travel, put the printer on a set, turn on the power and hold the striker casting of the printer so that the typewheel is free to rotate but cannot strike. Then select the letter "J" combination. Loosen the lock nut on the lower rotator magnet, which will not be operated, and turn the adjusting screw counter-clockwise. This will shorten the travel of the magnet plunger and move the typewheel slightly, taking the J out of the printing position. Now turn the adjusting screw slowly clockwise until the typewheel is again fully rotated with the letter "J" in front. It is best to try this two or three times, backing

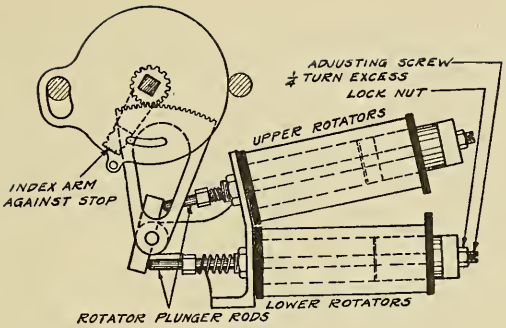



Fig. 40

off the adjusting screw and coming up slowly to the stopping point in order to determine the exact position. When the position is determined give the adjusting screw a quarter turn additional and tighten the lock nut. The same operation must be performed in adjusting the upper rotator magnet except that the letter "Z" should be selected instead of "J." Extreme care should be taken in adjusting the travel of the rotator plungers, for if the travel is too short the typewheel will not rotate far enough to bring the extreme rotation letters into the printing position. On the other hand, if the travel is too great, the magnet will be weak, due to excessive air gap, and the rotation will be slow.

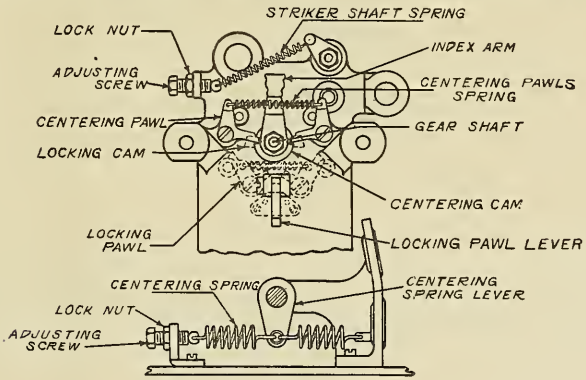



Fig. 16

28. **Rotator Shaft Centering Springs.** To balance these springs, first remove the striker shaft spring. This gives access to the centering pawls spring, which must be removed, thus allowing the pawls to drop free from the centering cam (Fig. 16). The striker shaft spring should be replaced after removing the centering pawls spring in order to prevent the typewheel from dropping forward and arresting the rotation during the adjustment of the centering springs. Disengage the locking pawls from the locking cam. This leaves the typewheel free to be rotated in either direction. Now, while the locking pawls are held free from the locking cam, rotate the typewheel to its extreme position and let go, then note the position in which the index arm comes to rest. Perform the same operation in the opposite direction and again note the final position of the

index arm. Adjust the rotator shaft centering springs by means of the spring adjusting screws so that the index arm will either come to rest in a vertical position or will come to rest a slight distance from the center after the typewheel has been rotated in one direction and will come to rest an equal distance on the other side of the center after the typewheel has been rotated in the opposite direction. After the adjustment is finally correct, tighten the lock nut and replace the centering pawls spring.

29. **Inker Lever Adjustment.** The platen top should now be replaced and the inker lever and bracket fastened on the inker plate with the thumb nut. Should the location of the inker plate change, for some reason, Figure 41 shows the proper adjustment of the inker lever, which in turn determines the position of the plate. Set the plate so that the inker will clear the paper by about 1/16 inch.

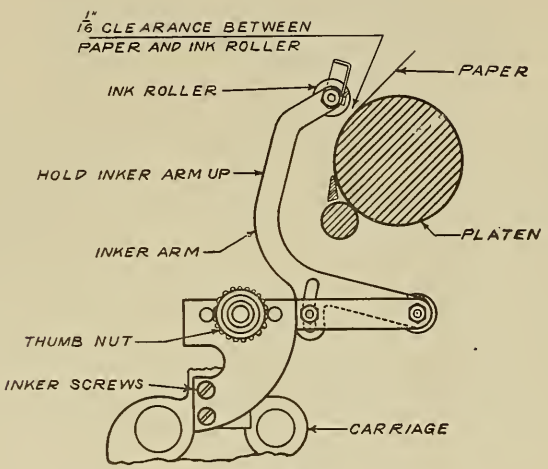



Fig. 41

30. **Line Feed Magnet.** Press the magnet yoke upward until the platen rotates and adjust the plunger rod so that both the line feed pawl and the stop pawl are meshed fully with the teeth of the ratchet at the same time the detent roll is resting between two of the teeth as shown in Figure 42. Be sure that the yoke is pressed upward as far as it will go in making this adjustment. To make sure that the travel of the magnet plunger is just sufficient to cause the pawl to mesh fully, it is advisable to shorten the travel until the pawls do not mesh fully and then gradually increase it until they just mesh fully and then tighten the lock nut. Overtravel or undertravel of the line feed plunger will cause uneven feeding of the paper or failure to feed. Improper working of the line feed mechanism is often caused by lack of oil on the platen and feed roll bearings. Therefore ascertain if these bearings are properly oiled before changing any adjustments.

31. **Feed Roll Tension.** The pressure of the feed roll against the platen can be regulated by means of the feed roll adjusting screws (Fig. 42). There are two of these, one at either end of the platen, and they regulate the tension of the feed roll springs. The adjusting screws shall be set so that the two tension springs have an equal value. If one spring is stronger than the other, the paper in feeding will tend to crowd to one side. If the adjusting screws are set so that the springs are very strong, the work of the line feed magnets in revolving the platen will be greatly increased and failure to feed may result. If the springs are too weak the paper will slip and feed unevenly. The springs

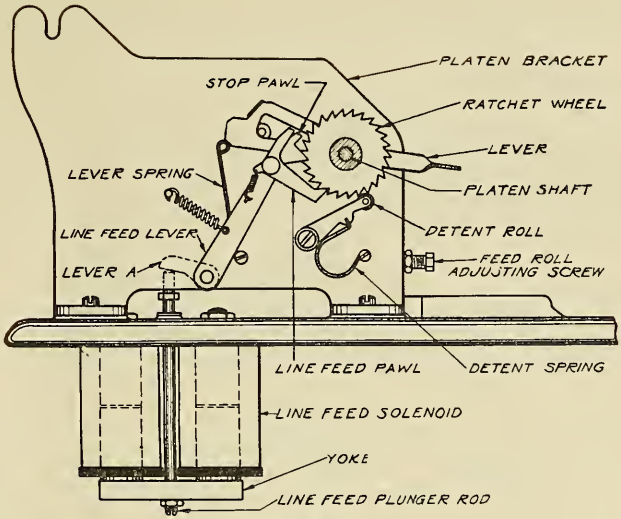

PLATEN BRACKET
STOP PAWL
RATCHET WHEEL
LEVER
LEVER SPRING
PLATEN SHAFT
LINE FEED LEVER
DETENT ROLL
LEVER A
FEED ROLL ADJUSTING SCREW
LINE FEED PAWL
DETENT SPRING
LINE FEED SOLENOID
YOKE
LINE FEED PLUNGER ROD

Fig. 42

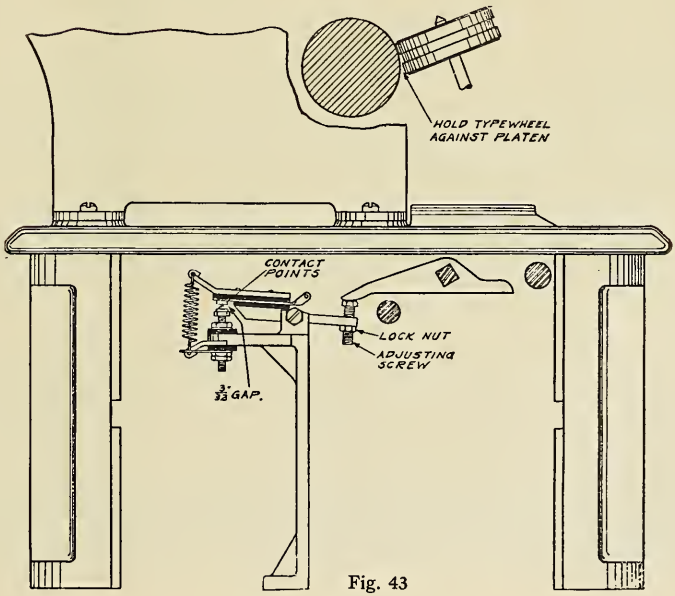

HOLD TYPEWHEEL AGAINST PLATEN
CONTACT POINTS
LOCK NUT
ADJUSTING SCREW
3/32" GAP.

Fig. 43

shall be set so that they are strong enough to feed the paper properly and still allow the paper to slip slightly and straighten itself when it becomes crowded to one side or the other.

32. **Main Break Contact Gap.** Hold the typewheel against the platen and regulate the main break armature adjusting screw so that the contact points stand open 3/32 inch (Fig. 43). After the adjustment has been made tighten the lock nut.

33. **Carriage Return Spring.** The tension of the carriage return spring can be increased by turning the screw in the center of the spring barrel clockwise and can be decreased by operating the escapement lever (Fig. 44). The tension of this spring shall be just sufficient to return the carriage smartly to the beginning of the line. In adjusting the carriage return spring the pneumatic carriage buffer should also be considered.

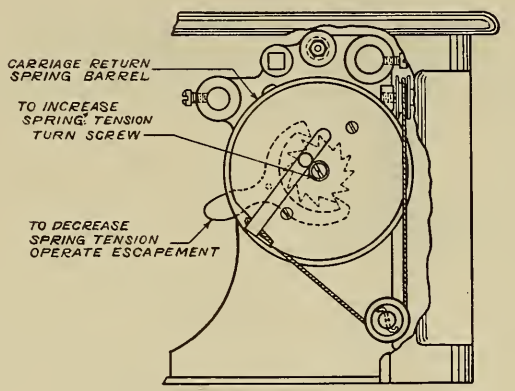



Fig. 44

34. **Carriage Buffer.** With the carriage return spring adjusted to about its proper value, the adjusting screw which regulates the air outlet of the pneumatic buffer shall be regulated so that the action of the buffer will take up the impact of the returning carriage, but still not cause the carriage to rebound. By turning the adjusting screw of the buffer clockwise the air outlet is decreased, increasing the retarding effect of the buffer. Turning the screw counter-clockwise increases the air outlet and decreases the retarding effect of the buffer.

35. **Carriage Return Magnet.** The travel of the carriage return plunger must be sufficient to raise the carriage return bar high enough for the bar stud to be engaged by the locking pawl. Press the plunger upward, loosen the lock nut and regulate the adjusting screw until the bar stud is engaged by the locking pawl, plus .010 inch clearance; then tighten the lock nut (Fig. 46).

36. **Spacer Magnet.** To regulate the travel of the spacer magnet plunger, put the printer on a set, turn on the power and hold the typewheel so that it cannot strike, then select any character. The spacer magnet will operate and remain operated while the typewheel is held. Loosen the lock nut and regulate the plunger rod until there is .004 inch clearance between the left hand end of the spacer pawl and the adjacent tooth of the spacer rack (Fig. 46).

37. **Spacer Lever Back Stop.** Press the carriage to the left and adjust the back stop so that there is .002 inch clearance between the back stop and the spacer lever. This clearance is necessary to insure the stop pawl dropping into the notch in the stationary rack after the spacer spring has moved the carriage to the right (Fig. 47).

**38. Space Pawl Springs.** The force exerted by the ends of the space pawl springs on the space pawls shall be not over six ounces. Slow carriage return action will result if these springs are too strong.

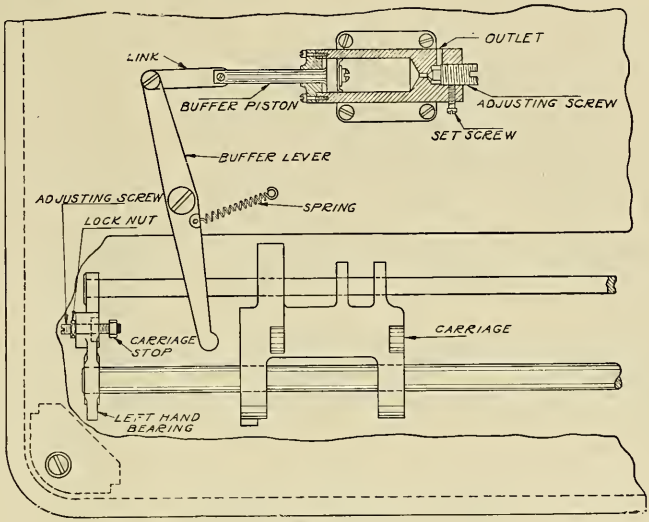



Fig. 20

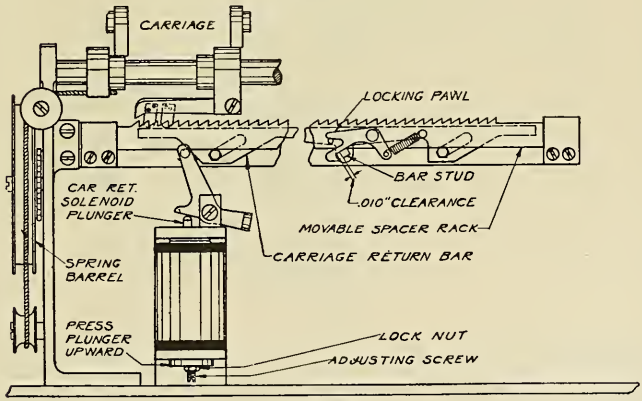



Fig. 45

**39. Spacer Spring.** To adjust the spacer spring correctly it is necessary to actually operate the printer while the adjustment is being made. Put the printer on a set and place in operation. Then loosen the lock nut of the spring adjusting screw and turn the screw counter-clockwise until the carriage fails to space properly, because the spring is too weak. Determine the point where the spring is just strong enough to space the carriage properly and then further strengthen the spring, counting the turns of the screw

until the printer fails to space properly, because the spring is too strong for the magnet, or double spacing occurs. Determine this point carefully and set the screw halfway between these two limits and tighten the lock nut (Fig. 46).

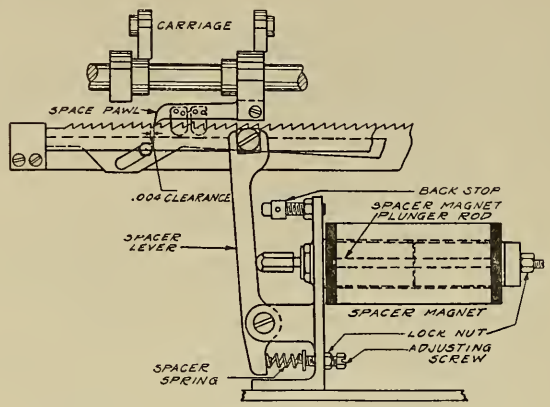



Fig. 46

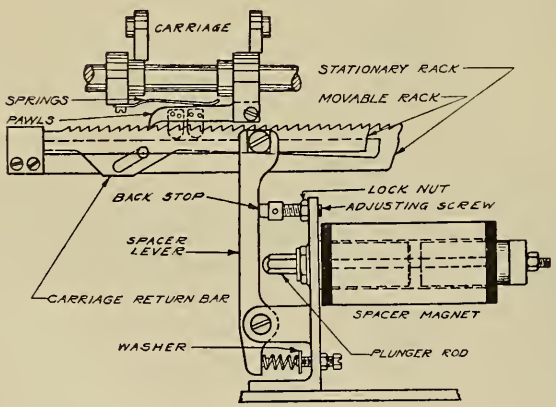



Fig. 47

40. **Carriage Stop.** The carriage stop which passes through the left hand bearing determines the initial position of the carriage (Fig. 20). It should be carefully adjusted, for if it extends too far to the right, the first two letters of the line will be crowded together, while if the stop is too far to the left, there will be too much space between the first two letters of the line. The carriage stop shall be adjusted so that when the carriage is resting against the stop and the spacer magnet is operated there is .004 inch clearance between the left end of the spacer pawl and the first notch of the spacer rack.

41. **Checking the Carriage Return Spring and Carriage Buffer Adjustment.** When the spacer mechanism is properly adjusted the adjustment of the carriage return spring

and the pneumatic carriage buffer shall be checked. To do this, put the printer in service at a speed of 65 words per minute and send to it the following test message: Blank, blank, blank, blank, car. ret., line feed, A, repeated several times. After the letter "A" has been printed each time, draw the carriage quickly to the right hand end of the line while the blanks are being received. Note if the letter "A" is always printed in the initial position. If the carriage is not returning quickly enough, due to the carriage return spring being too weak or to the retarding effect of the buffer being too great, the letter "A" will be printed before the carriage is all the way back. In this case either the carriage return spring or the pneumatic buffer must be adjusted until the carriage returns quickly enough. The effect of the buffer must be just enough to prevent the carriage from jarring the printer when it strikes the carriage stop. If the buffer adjusting screw is screwed in too far the carriage will bounce when it strikes the buffer lever and will not return all the way to the beginning of the line. The carriage return spring must be no stronger than is necessary, as excess tension of this spring acts against the spacer spring and reduces the margin of adjustment of the spacer spring. In no case shall the carriage tension be strong enough to prevent a force of 2½ pounds from pulling the carriage to the right when the carriage rods are well oiled. If during this checking the carriage return spring adjustment has to be changed, the spacer spring adjustment shall again be checked.

**42. Height of Figures.** The height of the figures is regulated by the position of the shift lever adjusting screw. This adjustment is made after the figures magnet adjustment, which previously has been explained. Write a few characters, alternating between letters and figures. If the figures are not in alignment with the letters, move the shift lever adjusting screw (Fig. 29) backward or forward until the proper alignment is obtained, then tighten the lock nut.

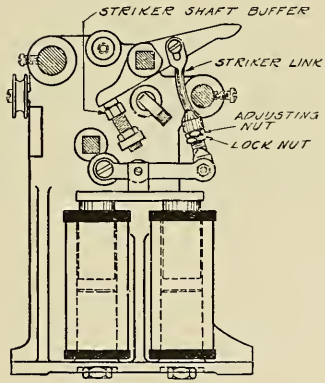



Fig. 48

**43. Adjustable Striker Link.** The strength of the blow of the typewheel against the platen may be regulated by means of the adjustable striker link (Fig. 48). This link can be lengthened by loosening the lock nut and turning the adjustable nut counter-clockwise, as seen from the top of the printer. The link can be shortened by reversing this operation. Lengthening the link weakens the blow and shortening the link makes the blow heavier. To determine the proper length of this link, write figures and lengthen the link until the figures just barely print. Then shorten the link until all the figures print clearly and tighten the lock nut.

**44. Improper Inking.** The position of the ink wheel has a direct bearing on the quality of the copy. If the ink wheel is too high the tops of the letters will print darker than

the lower parts, or if the ink wheel is too low the opposite will be the result. If the ink wheel is displaced sidewise, one side of the letter will print darker than the other. The position of the ink wheel shall be such that the bottom of the letter to be printed will strike the ink wheel in the center so that the ink wheel will roll across the entire letter, inking it evenly. When putting on a new ink wheel, rub off the surplus ink with a piece of paper. Care should be taken to keep the ink wheel bearing clean so that the ink wheel may revolve freely. No oil should be used on the inker, as oil interferes with good water copies.

45. **Replacing Inker Lever.** When replacing the inker lever after having taken it off, make sure that it is adjusted according to Figure 41. If the inker is set too far forward it will strike the paper and mark it when it is thrown forward by the typewheel. If the inker is set too far back it will be very close to the typewheel and will not allow proper inking of the type.

46. **Side Printing.** Side printing—that is, printing part of the letter adjacent to the one selected with the selected letter—is most frequently caused by the typewheel striking too heavily. The strength of the blow may be regulated by the adjustable striker link as described in connection with Figure 48. Side printing is caused also by the letters of the typewheel becoming worn down. When this is the case there is no remedy except to put on a new typewheel.

47. **Position of Platen.** If the letters do not print evenly—that is, if the top of the letter is printed heavier than the bottom, or vice versa—it may be due either to improper inking or to the position of the platen. In order to determine whether this is caused by improper inking or position of the platen roll, take a carbon copy. If the letters are printed evenly on the carbon copy and are not printed evenly on the ink copy, the trouble is due to improper inking. However, if the letters are not printed evenly on either copy, the trouble is due to the improper position of the platen roll. The platen roll is either too far forward or too far back, which prevent the letter from striking the paper squarely. The holes in the platen bracket, through which the retaining screws pass, are slotted, so that the platen can be shifted forward or backward by loosening these screws. Press the typewheel against the platen, after rotating ir to the letter "E" and sight along the platen to see if the letter is striking the platen squarely. If the bottom of the letter touches the platen and the top does not, shift the platen backward until the letter strikes evenly. If the top of the letter is touching the platen, but the bottom is not, reverse this operation. Of course this adjustment can be made also by taking a carbon copy and noting if the characters are heavier on top or bottom and shifting the platen until the characters print evenly.

48. **Paper Guides.** It is very important that the paper guides fit snugly against the platen. If these guides become bent outward the paper is not held tightly around the platen and a poor impression is the result. Occasionally the paper guides become bent outward so much that the typewheel in printing strikes against the guides and the characters on the typewheel become cut, ruining the wheel. In this case they must be removed and reformed so as to fit snugly against the platen.

49. **Coil Resistances:**

No. 8— 83 ohms.....Rotator Magnet

No. 29—1000 ohms.....Print Relay

No. 99— 10 ohms 1st winding, 12 ohms 2d winding.....Cut-out Relay

No. 100— 150 ohms.....Figures Magnet, Carriage Return Magnet

No. 101— 74 ohms.....Selecting Magnet

No. 104— 82 ohms 1st winding, 1200 ohms 2d winding.....Sixth Pulse Relay

**Coil Resistances:—(Cont.)**

No. 106— 47 ohms.....Spacer Magnet

No. 107— 27 ohms.....Striker Magnet

No. 108— 50 ohms.....Reset Magnet (right)

No. 109— 82 ohms..... { Line Feed Magnet / Drum Magnet

No. 112— 142 ohms.....Bell Magnet

No. 113— 128 ohms 1st winding } .....Letters Magnet
172 ohms 2d winding }

No. 119— 44 ohms.....Reset Magnet (left)

No. 120— 750 ohms 1st winding } .....Fourth Pulse Relay
1200 ohms 2d winding }

No. 122—2530 ohms.....Main Break Relay

50. **Arrangement of Characters on Typewheel:**

| Characters without 4th pulse | | Characters with 4th pulse |
|---|---|---|
| Z Q P Y W U L H S I A T E | | N O R D C F M G V B K X J |
| " 1 0 6 2 7 ) £ 8 - 5 3 | | , 9 4 $ : . & ; ? ( / |
| Long rotation letters | Point of typewheel normally nearest platen | Long rotation letters |

51. **Wiring Diagram.** A complete actual wiring diagram of the printer is shown in Figure 49.

52. **Cable Form.** For convenience in wiring printers in which the cable form must be replaced Figure 50, which shows the cable form, and Figure 51, which shows the printer base casting with the holes through which the cable form passes lettered to correspond with the circles in Figure 50, are included.

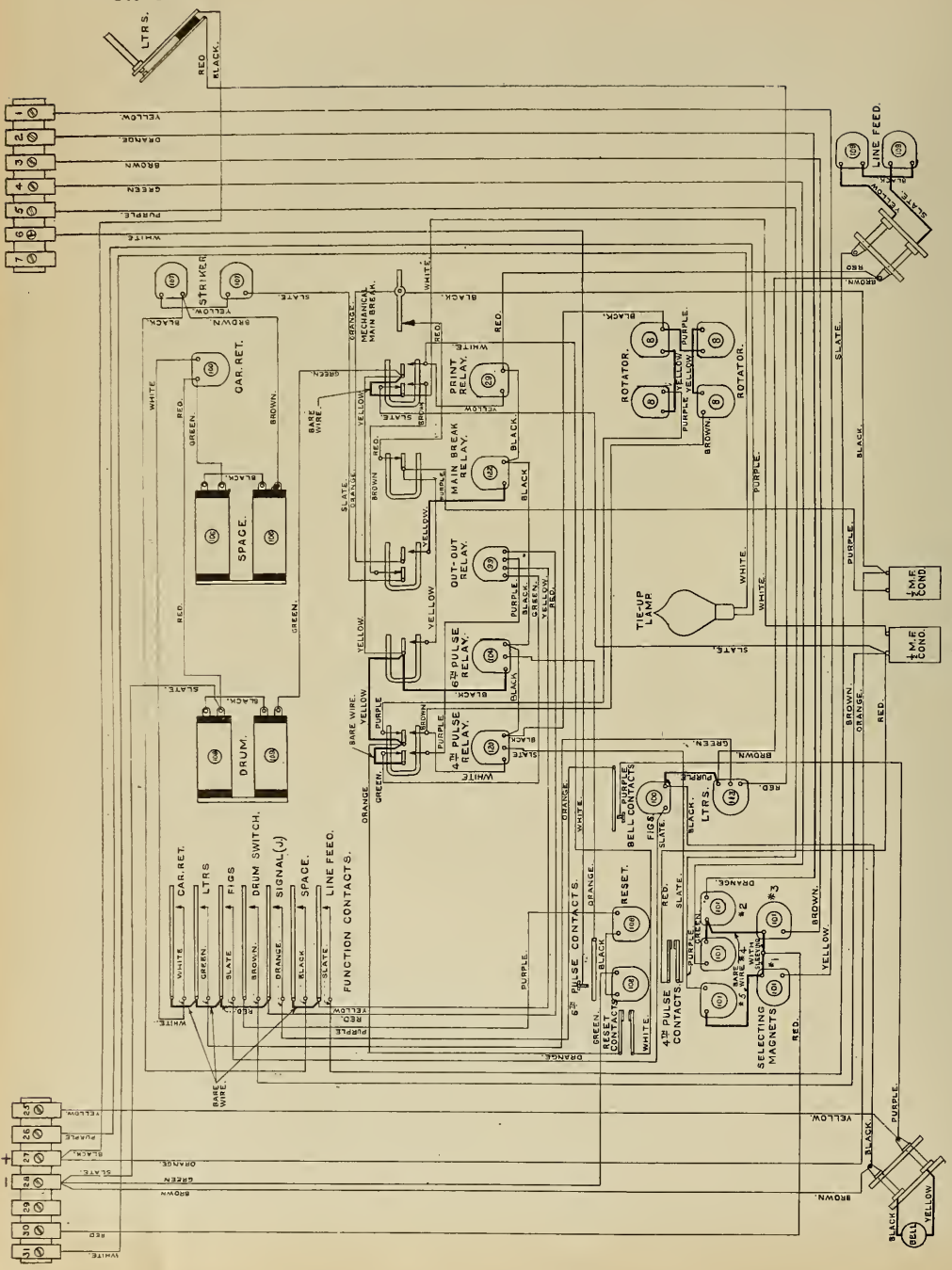

LTRS.
RED
BLACK
YELLOW
ORANGE
BROWN
GREEN
PURPLE
WHITE
STRIKER
SLATE
BLACK
BROWN
CAR. RET.
GREEN
WHITE
RED
BROWN
BARE WIRE
SPACE.
DRUM.
BARE WIRE
YELLOW
PURPLE
ORANGE
GREEN
FUNCTION CONTACTS.
CAR. RET.
LTRS
FIGS
DRUM SWITCH.
SIGNAL (J)
SPACE.
LINE FEED.
BARE WIRE
MECHANICAL MAIN BREAK.
ORANGE
RED
WHITE
BLACK
PRINT RELAY.
MAIN BREAK RELAY.
OUT-OUT RELAY.
6TH PULSE RELAY.
4TH PULSE RELAY.
SLATE
YELLOW
BROWN
PURPLE
BLACK
GREEN
ROTATOR.
PURPLE
YELLOW
BROWN
TIE-UP LAMP
WHITE
SLATE
1 M.F. COND.
1 M.F. COND.
BROWN
ORANGE
RED
LINE FEED.
SLATE
YELLOW
RED
BROWN
LTRS.
FIGS
BELL CONTACTS
PURPLE
BLACK
RED
GREEN
BROWN
6TH PULSE CONTACTS.
RESET.
RESET CONTACTS
4TH PULSE CONTACTS.
SELECTING MAGNETS
#1
#2
#3
#4
#5
BARE WIRE
ORANGE
RED
BROWN
YELLOW
PURPLE
WHITE
BLACK
SLATE
GREEN
BELL
BLACK
YELLOW
BROWN
PURPLE
YELLOW
BLACK
SLATE
ORANGE
GREEN
BROWN
RED
WHITE
BARE WIRE

Fig. 49

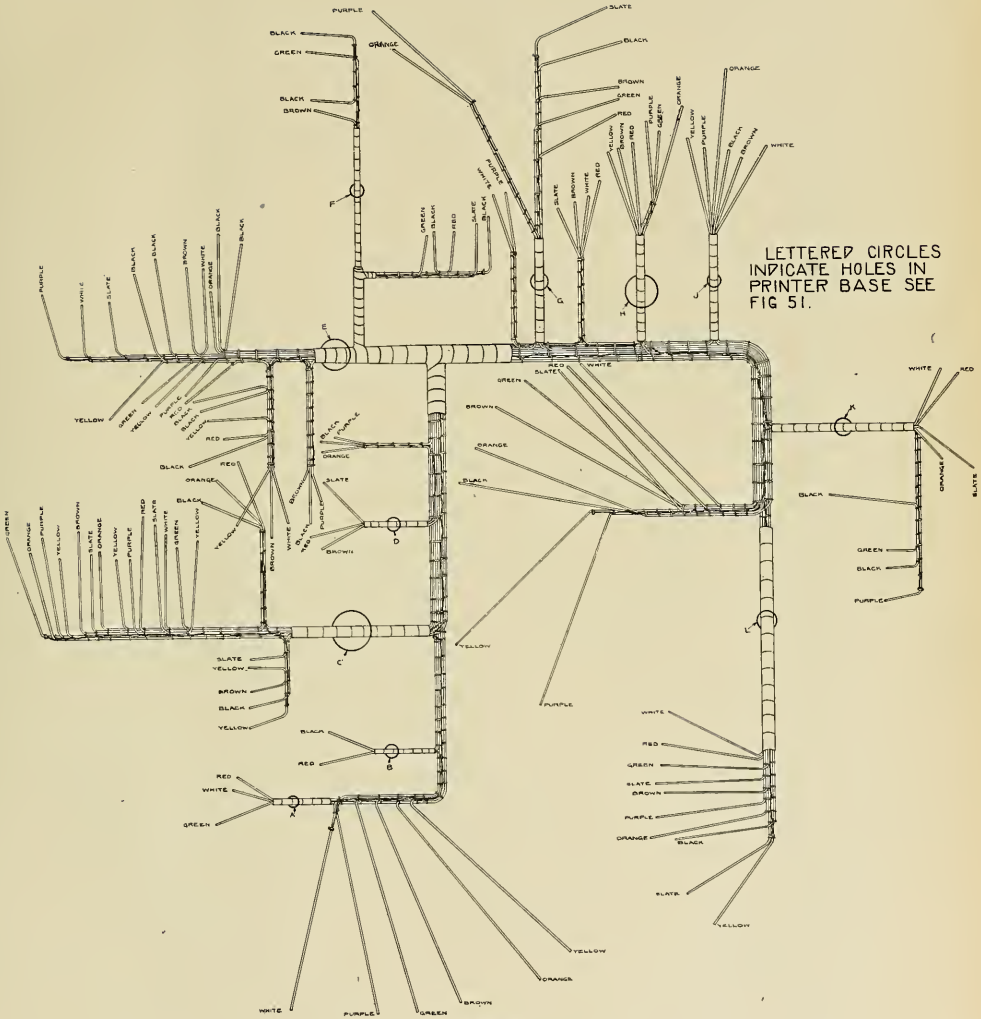



Fig. 50

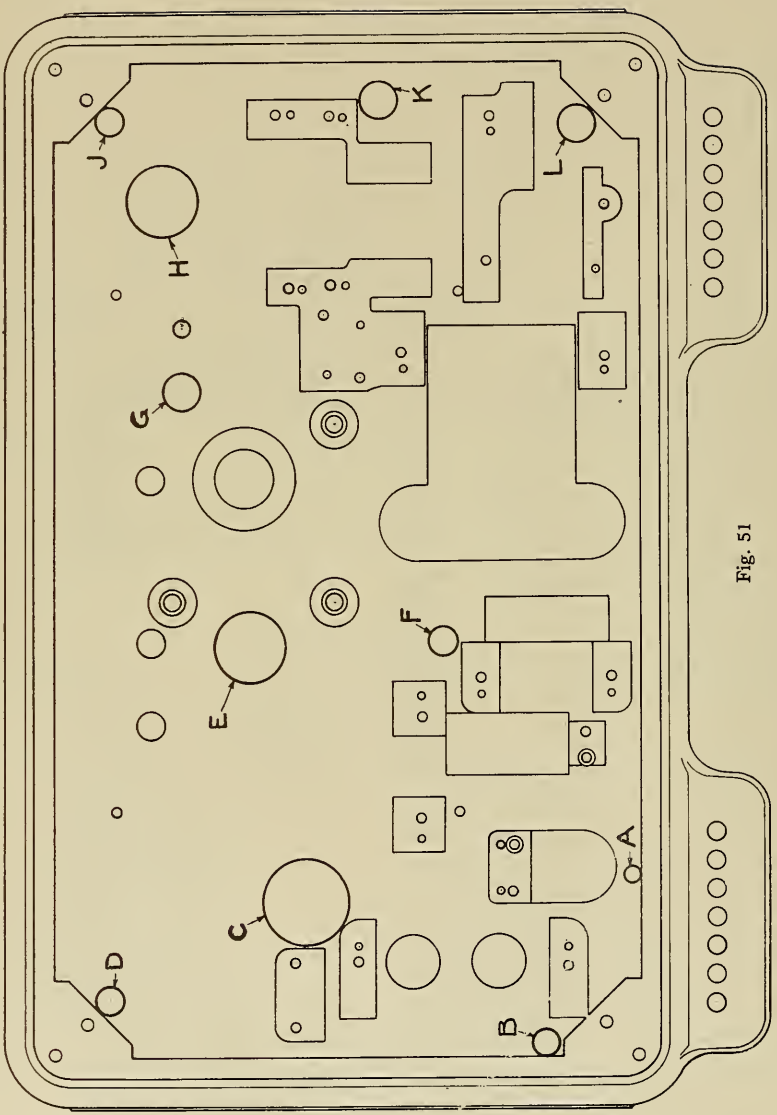



Fig. 51

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 5-B

PRINTER 3-A

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These Specifications are the property of the Western Union Telegraph Company and shall not be published.

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| Intermediate Levers | 3 |
| Sixth Pulse and Operating Magnet | 4 |
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**SPECIFICATIONS INCLUDED:** None.

**PHOTOGRAPHS AND DRAWINGS:**


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| 2 | 8501- -2 | Printer 3-A Selector Unit. |
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| 5 | 8502- -7 | Printer 3-A Printing and Spacing. |
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| 15 | 17034- -9 | Cable Form for Printer 3-A. |
| 16 | 17033- -3 | Cable Form and Connections for Printer 3-A Relay Box. |

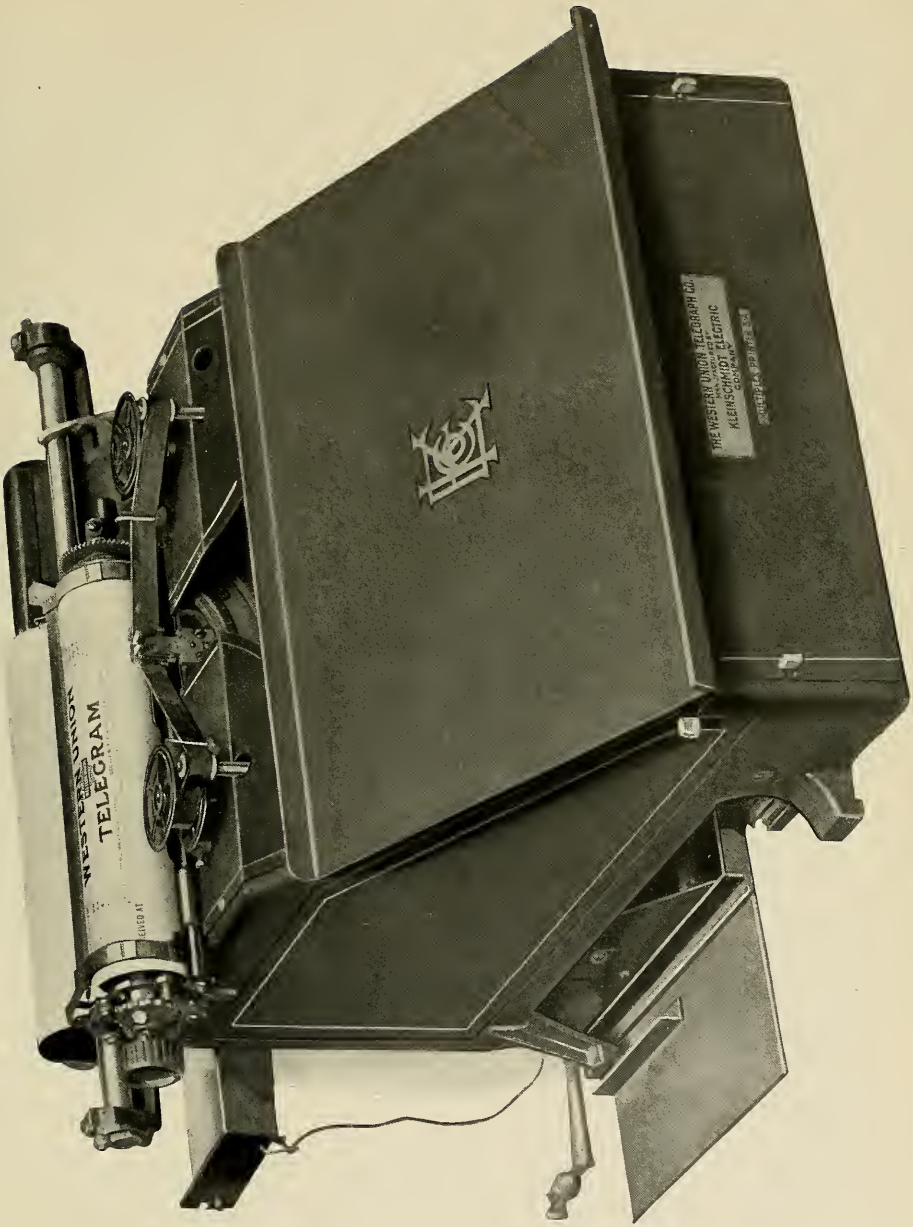

TELEGRAM
THE WESTERN UNION TELEGRAPH CO.
KLEINSCHMIDT ELECTRIC
COMPANY

Fig. 1

## MULTIPLEX PRINTER 3-A

1. Section 1 described an elementary printer which consisted fundamentally of a typewriter with a separate, electrically operated selecting unit. Such a piece of apparatus would obviously be impractical and in the 3-A Printer which is described in this section the selecting and printing units have been consolidated into a single machine. This printer mechanically performs the greater part of its function and the printing is done by type bars. For the sake of convenience part of the relays, condensers, and resistances used in the machine are assembled in a metal box which is connected to the printer proper by spring clips. A special mounting or adapter plate is also furnished with the printer

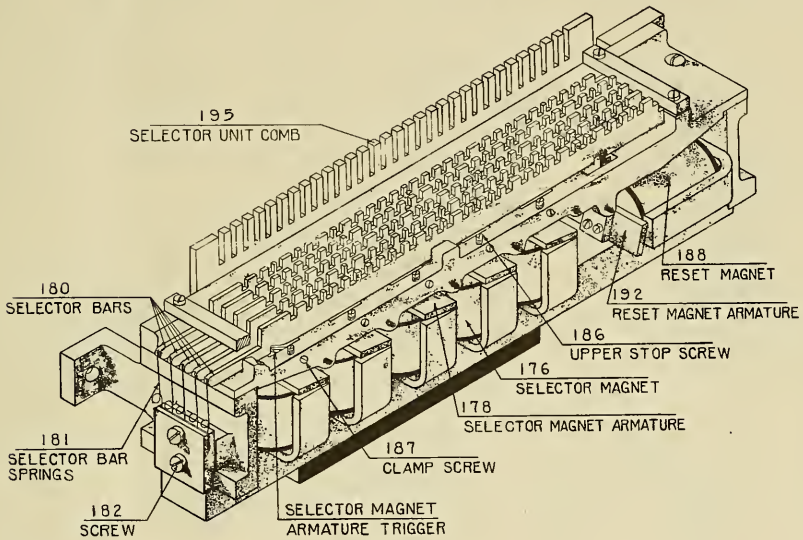



Fig. 2

2. Figure 2 shows the complete selector unit in perspective. It consists principally of five selector magnets with their armatures, five selector bars, the selector bar springs, a reset magnet and a selector unit comb. The five selector bars are normally held toward the left of the unit against their respective selector bar springs by means of small triggers attached to each of the selector magnet armatures. These triggers rest in small notches on the under side of the selector bars. Each of the five selector magnets, numbered from left to right, is connected electrically to a segment of the receiving ring of the Multiplex distributor and as the distributor brushes pass over the five segments, any one or all of the selector magnets may be energized, according to the code combination of the received signals. As the armature of a selector magnet is actuated it withdraws the small trigger, referred to above, from the notch in the selector bar, thereby allowing the latter to be forced to the right by its selector bar spring. As will be seen from Figure 2, each selector bar has a number of slots cut in the upper side spaced different distances apart. These slots are so cut that when one or more selector bars are moved from their normal position to the right of the unit there will be, at some point, five of the selector bar slots in line with one of the slots in the selector unit comb.

3. Just above the selector bars and at right angles to them are 31 intermediate levers (Fig. 5), each located in a slot of the selector unit comb. Normally, the intermediate levers are held just above the selector bars by means of the restoring bar, which extends

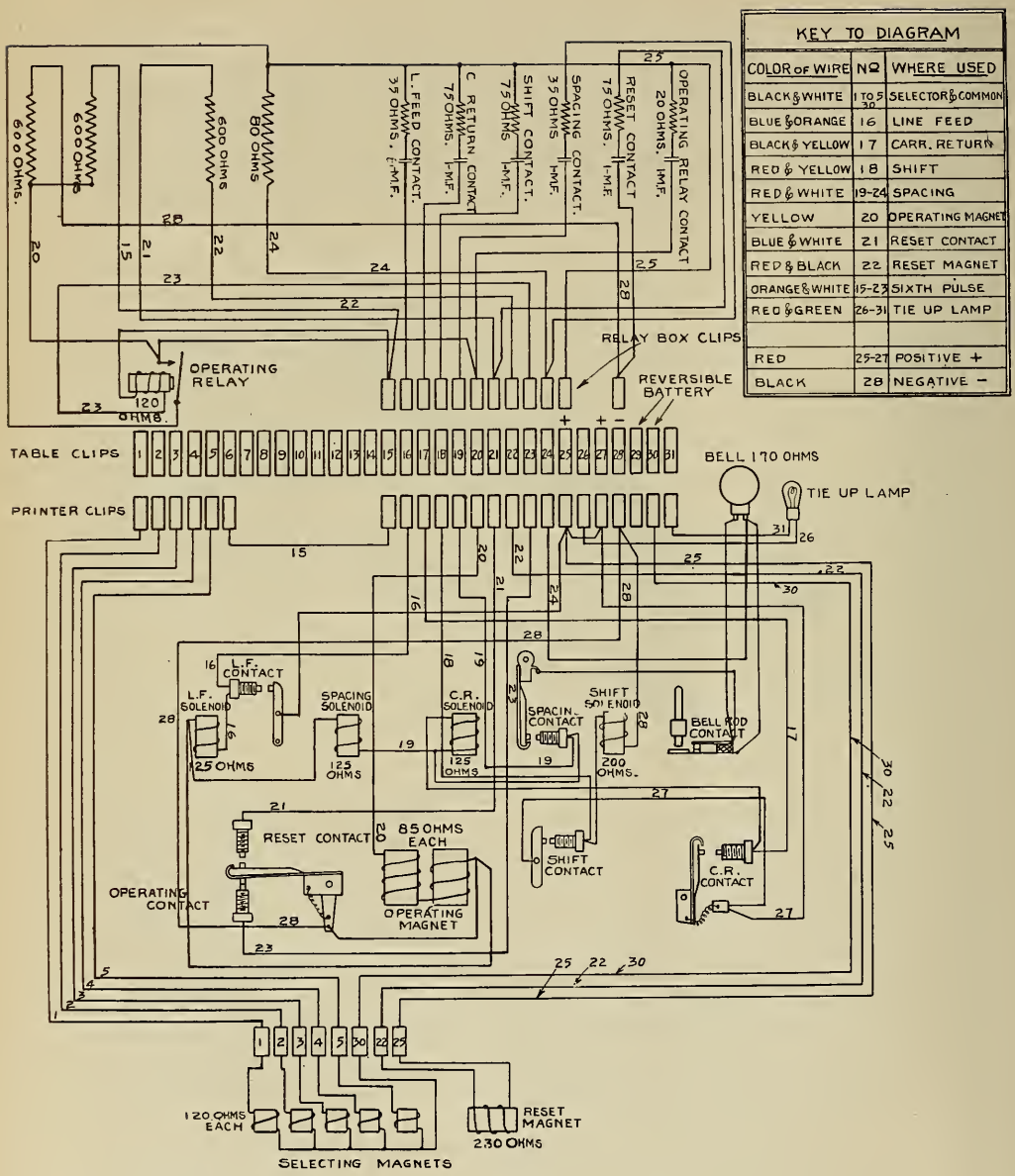
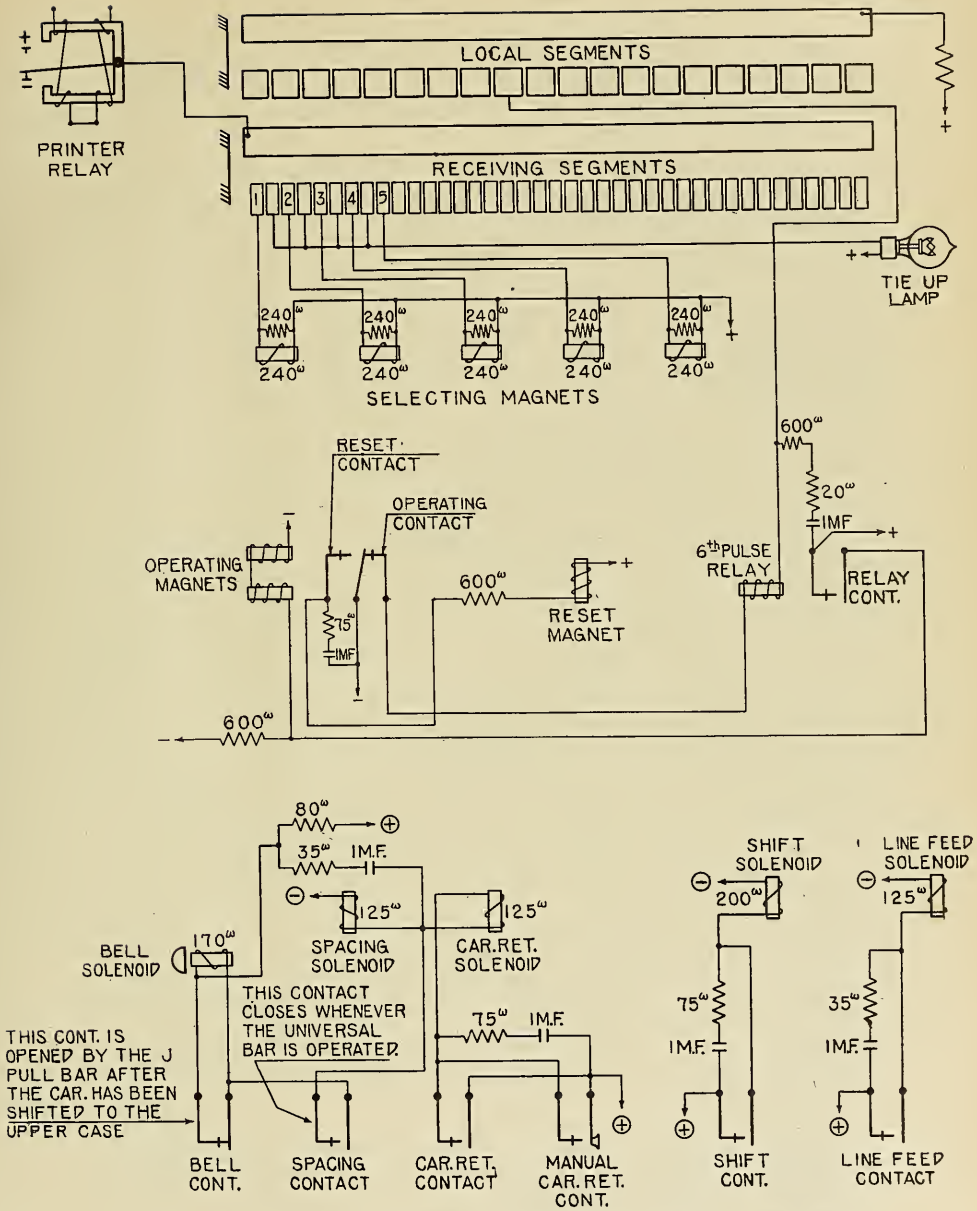

KEY TO DIAGRAM
COLOR OF WIRE | NO | WHERE USED
BLACK & WHITE | 1 TO 5 30 | SELECTOR & COMMON
BLUE & ORANGE | 16 | LINE FEED
BLACK & YELLOW | 17 | CARR. RETURN
RED & YELLOW | 18 | SHIFT
RED & WHITE | 19-24 | SPACING
YELLOW | 20 | OPERATING MAGNET
BLUE & WHITE | 21 | RESET CONTACT
RED & BLACK | 22 | RESET MAGNET
ORANGE & WHITE | 15-23 | SIXTH PULSE
RED & GREEN | 26-31 | TIE UP LAMP
RED | 25-27 | POSITIVE +
BLACK | 28 | NEGATIVE –
600 OHMS.
600 OHMS
600 OHMS
80 OHMS
L. FEED CONTACT. 35 OHMS. 1-M.F.
C. RETURN CONTACT 75 OHMS. 1-M.F.
SHIFT CONTACT. 75 OHMS 1-M.F.
SPACING CONTACT. 35 OHMS 1-M.F.
RESET CONTACT 75 OHMS. 1-M.F.
OPERATING RELAY CONTACT 20 OHMS. 1-M.F.
OPERATING RELAY
120 OHMS.
RELAY BOX CLIPS
REVERSIBLE BATTERY
TABLE CLIPS
PRINTER CLIPS
BELL 170 OHMS
TIE UP LAMP
L.F. CONTACT
L.F. SOLENOID
SPACING SOLENOID
C.R. SOLENOID
SPACIN. CONTACT
SHIFT SOLENOID
BELL ROD CONTACT
125 OHMS
125 OHMS
125 OHMS
200 OHMS.
RESET CONTACT
85 OHMS EACH
OPERATING CONTACT
OPERATING MAGNET
SHIFT CONTACT
C.R. CONTACT
120 OHMS EACH
SELECTING MAGNETS
RESET MAGNET
230 OHMS

Fig. 3




THE BATTERY POLARITIES MARKED ⊕ OR ⊖ REMAIN CONSTANT AS SHOWN FOR ALL CHANNELS. ALL OTHER POTENTIALS ARE CORRECT ONLY FOR A AND C CHANNELS. FOR B AND D CHANNELS THESE POTENTIALS ARE REVERSED.

Fig. 4

across the tops of all the intermediate levers. When a character combination is received from the distributor, one or more of the selector magnets is energized and the corresponding selector bars moved to the right. This, as previously stated, forms a continuous slot immediately under some one intermediate lever, the particular one depending upon the code combination selected.

4. After the receiving distributor brush has passed over the five receiving segments and one or more of the selector magnets has been energized, the local distributor brush passes over the operating or sixth pulse segment in the local ring and energizes the operating relay (Figs. 3 and 4) of the printer, located in the relay box. The closing of the contact of the operating relay actuates the operating magnet (Fig. 5) and at the same time closes a locking circuit on itself, which is maintained until broken at the operating contact, by the operation of the restoring bar. The circuit of the operating relay, operating magnet and operating contact is shown on Figures 3 and 4, the clips numbered 1 to 31 representing the clips on the operating table, Nos. 1 to 5 being connected to the five receiving segments of the distributor and No. 6 to the operating segment of the local ring of the distributor. Referring again to Figure 5, the energizing of the operating magnet actuates its armature, causing it to move the operating lever about its shaft, thereby moving the operating bail to the left. At the same time the connecting link rod is forced down, rocking the restoring lever on its shaft and consequently raising the restoring bar.

5. As the restoring bar rises, the intermediate lever spring, of the lever under which the slot in the selector bars has been prepared, causes that particular lever to be drawn into the slot, its left end rises and carries its pull bar with it, placing the hooked end of the pull bar immediately in front of the operating bail, which, as stated, was moved to the left by the actuation of the operating magnet armature. The operating contact that breaks the current in the operating magnet is located to the left of the operating unit when facing the front of the printer. The operating contact lever (Figs. 5 and 12) carries an upper and lower contact point. Directly above and below these contact points are contact screws. The lower set of contacts is known as the operating contacts and they are normally held closed by the spring which is attached to the operating contact lever block. The upper set of contacts controls the reset magnet on the selector unit (Fig. 2) and is called the reset contacts. The operating contact lever turns about a stud when its free end is lifted by the adjustment screw on the restoring bar. When the operating magnet is energized, after a selection is made on the selector bars, it attracts the operating lever and bail (Fig. 5). During this time and before the operating lever reaches its back stop screw the operating contact is opened and the reset contact is closed by means of the connecting link rod and the restoring bar. Just as the bail passes the hooks on the pull bars, and before the operating lever reaches its stop, the restoring bar closes the reset contacts and the end of the trip rod (Fig. 12) springs under the catch on the operating contact lever at p. This locks the contact lever in its upper position with the reset contacts closed until the trip rod is moved from under the catch at p. As long as the reset contacts are closed the reset magnet is energized, but during this time an intermediate lever (Fig. 5) is in a slot formed by the selector bars and therefore the reset magnet cannot force the selector bars to the left. Just as soon as the operating lever returns and engages the pull bar hook in its path the restoring bar lifts the intermediate lever out of the slot in the selector bars and they immediately snap back to the left under the influence of the reset magnet. When they reach their extreme left hand position number 5 selector bar (Fig. 12) trips the trigger, thereby turning the trip rod clockwise and releasing the contact lever, which immediately opens the reset contacts and closes the operating contacts ready for the next operating impulse from the 6th pulse relay. The breaking of the reset contacts de-energizes the reset magnet and allows the selector bars to settle back against the selector armature triggers ready for the next selection.

6. As the operating contact lever is raised, its lower contact opens the circuit of the operating relay (Figs. 3 and 4) and consequently the circuit of the operating magnet, thereby allowing the operating lever to return to its original position. As the latter returns, the operating bail engages with the selected pull bar. Since the pull bar is linked to the type bar through the vertical bar, the operating bail, by its engagement

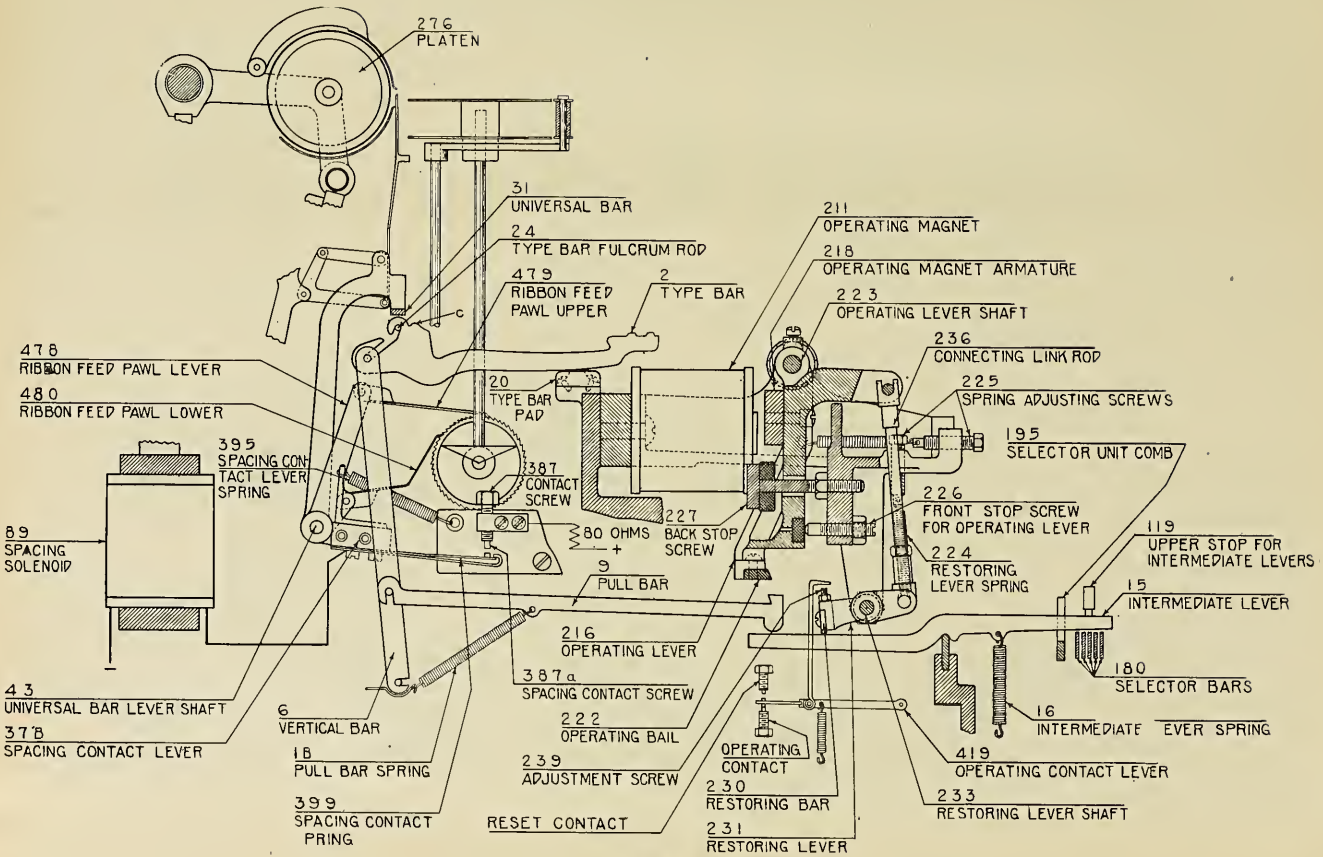

276
PLATEN
31
UNIVERSAL BAR
24
TYPE BAR FULCRUM ROD
479
RIBBON FEED
PAWL UPPER
2
TYPE BAR
211
OPERATING MAGNET
218
OPERATING MAGNET ARMATURE
223
OPERATING LEVER SHAFT
236
CONNECTING LINK ROD
225
SPRING ADJUSTING SCREWS
195
SELECTOR UNIT COMB
478
RIBBON FEED PAWL LEVER
480
RIBBON FEED PAWL LOWER
20
TYPE BAR
PAD
395
SPACING CONTACT LEVER
SPRING
387
CONTACT
SCREW
80 OHMS
227
BACK STOP
SCREW
226
FRONT STOP SCREW
FOR OPERATING LEVER
224
RESTORING
LEVER SPRING
119
UPPER STOP FOR
INTERMEDIATE LEVERS
89
SPACING
SOLENOID
9
PULL BAR
15
INTERMEDIATE LEVER
216
OPERATING LEVER
180
SELECTOR BARS
43
UNIVERSAL BAR LEVER SHAFT
387a
SPACING CONTACT SCREW
16
INTERMEDIATE LEVER SPRING
6
VERTICAL BAR
222
OPERATING BAIL
378
SPACING CONTACT LEVER
18
PULL BAR SPRING
239
ADJUSTMENT SCREW
OPERATING
CONTACT
419
OPERATING CONTACT LEVER
399
SPACING CONTACT
PRING
RESET CONTACT
230
RESTORING BAR
233
RESTORING LEVER SHAFT
231
RESTORING LEVER

Fig. 5

with the hook of the pull bar, will throw the type bar against the ribbon and paper and against the platen, causing the selected character to be printed. When the operating lever again reaches its stop screw the sudden stop causes the pull bar to overthrow and it is thus disengaged from the bail and returned to normal by its spring.

**7.** Immediately after the operating bail engages with the pull bar, the restoring bar forces the intermediate lever out of the slot formed by the selector bars, thereby allowing the reset magnet, the circuit of which was closed by the operating contact lever on its upper contact, to restore all the selector bars to their normal position to the left. The resetting of the intermediate lever and the simultaneous restoring of the selector bars to their normal position at this time permits the selector bars to set up the next selection while the printer is finishing the function previously selected.

**8.** Referring to Figure 5, as the type bar nears the platen and just before it strikes, a rounded portion c of the type bar near its fulcrum rod strikes the universal bar and forces it back. This operates the spacing contact lever and closes the spacing contact, thus energizing the spacing solenoid. Figure 5 shows the spacing solenoid schematically but not its operation. Referring to Figure 8, the spacing pawl rests on the spacing ratchet wheel. As the spacing solenoid is energized its plunger, by means of a link, pulls down the right end of the spacing pawl lever, causing the spacing pawl to move upward in a position ready to engage another tooth of the spacing ratchet wheel. When the type bar has finished its operation (Fig. 5), and just before it falls away from the universal bar, the circuit of the spacing solenoid is broken by the spacing contact lever and the spacing spring (Fig. 8) returns the spacing pawl lever to normal, causing the pawl to move the ratchet wheel one tooth, thus spacing the carriage for the next character to be printed.

**9.** In order to review the operation of the printer as thus far described, we will assume that the letter "E" is to be printed. The sequence of operations will be as indicated in the following paragraph:

**10. SEQUENCE OF OPERATION**

| Selecting Mechanism | Operating Mechanism | Spacing Mechanism |
|---|---|---|
| 1. No. 1 selector magnet operated | | |
| 2. No. 1 code bar shifted to right | | |
| 3. 6th pulse relay operated | | |
| 4. 6th pulse relay locked up | 1. Operating magnet energized (operating contact normally closed) | |
| 5. Intermediate lever selected | 2. Operating lever moved to rear | |
| | 3. Restoring bar raised | |
| 6. Reset contact closed | 4. Pull bar selected | |
| 7. Intermediate lever (restored) | 5. Operating contact broken and operating magnet de-energized | |
| 8. No. 1 code bar shifted to left (restored) | | |
| | 6. Operating lever restored | |
| | | 1. Spacing contact closed |
| | 7. Letter "E" printed | 2. Spacing solenoid operated. Spacing pawl raised and spacing spring extended |
| | | 3. Spacing contact opened |
| | 8. Pull bar restored | 4. Carriage spaced |
| | 9. Operating contact closed (restored) | |

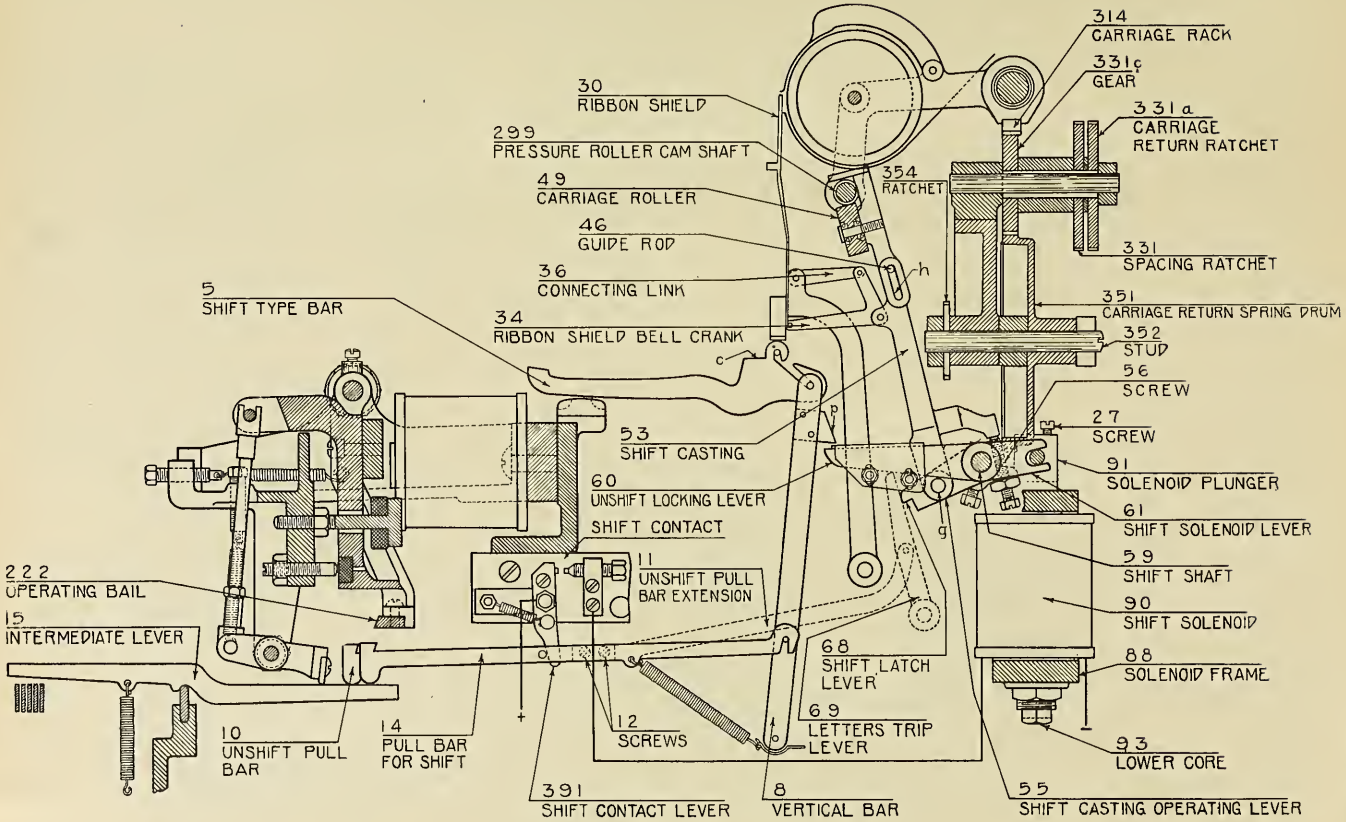

314
CARRIAGE RACK
331c
GEAR
331a
CARRIAGE
RETURN RATCHET
30
RIBBON SHIELD
299
PRESSURE ROLLER CAM SHAFT
354
RATCHET
49
CARRIAGE ROLLER
46
GUIDE ROD
331
SPACING RATCHET
36
CONNECTING LINK
351
CARRIAGE RETURN SPRING DRUM
5
SHIFT TYPE BAR
34
RIBBON SHIELD BELL CRANK
352
STUD
56
SCREW
27
SCREW
53
SHIFT CASTING
91
SOLENOID PLUNGER
60
UNSHIFT LOCKING LEVER
61
SHIFT SOLENOID LEVER
SHIFT CONTACT
59
SHIFT SHAFT
222
OPERATING BAIL
11
UNSHIFT PULL
BAR EXTENSION
90
SHIFT SOLENOID
15
INTERMEDIATE LEVER
68
SHIFT LATCH
LEVER
88
SOLENOID FRAME
10
UNSHIFT PULL
BAR
14
PULL BAR
FOR SHIFT
12
SCREWS
69
LETTERS TRIP
LEVER
93
LOWER CORE
391
SHIFT CONTACT LEVER
8
VERTICAL BAR
55
SHIFT CASTING OPERATING LEVER

Fig. 6

11. The operation of printing any letter or character is similar to the operation described for the letter "E," except that other selector bars are operated as determined by the combination representing the letter or character to be printed.

12. If we wish to perform some function other than printing, however, the operation must be modified somewhat for each of the different additional functions that the printer is built to perform.

13. The operation of spacing the carriage without printing a letter, as for a space between words, is the simplest function to perform. This operation is the same as for the printing of a letter, except that type bar selected by the code combination, representing the "space," is not equipped with type.

14. Should it be desired to print a figure or upper case character of a letter it is first necessary to operate the Figures mechanism, which will raise the platen so that the printing point or printing line of the platen will be opposite the upper case character of the type block on the type bar. The proper intermediate lever for starting the operation of the Figures train is selected by the code combination which operates the 1st, 2nd, 4th and 5th selector bars. Referring to Figure 6, the selection of the code bars, the action of the operating magnet, the operation of the intermediate lever and the positioning of the shift pull bar are, up to this point, the same as previously described for printing. The shift pull bar in addition to throwing the dummy type bar through the medium of the vertical bar permits the shift contact lever to close the circuit of the shift solenoid through the shift contact. The type bar just mentioned has no curved portion at c like type bars for printing and spacing; therefore, the universal bar and, consequently, the spacing solenoid are not operated. The function of the dummy type bar is merely to prolong the time of contact of the shift contact which remains closed until the shift pull bar is released in the same manner as previously described. When the shift solenoid is energized its plunger rocks the shift shaft by means of the shift solenoid lever. This shaft carries the shift latch lever, the unshift locking lever and the shift casting operating lever, all of which are raised by the operation of the shift solenoid. The latch lever engages with the unshift or letters trip lever which holds the platen in the raised or shifted position. The projection p on the shift vertical bar is moved from the path of the extension of the unshift locking lever by the shift pull bar, thus permitting the shift shaft to be rocked by the action of the solenoid plunger. The shift casting operating lever is linked at g to the shift casting, which carries, at its upper end, the ball bearing carriage roller, on which the pressure roller cam shaft of the carriage rides. The slotted part h of the casting slides on a guide rod which is fastened to the frame of the machine. The movement of the shaft casting carries with it the ball bearing roller and, consequently, the carriage and the platen to the upper case position. The platen will remain locked in the raised position and permit the printing of any upper case character until returned to its normal position by the operation of the Letters or Unshift selection.

15. When the unshift or letters trip lever, which is linked to an extension of the unshift pull bar, engages with the latch lever the unshift pull bar, which normally rests slightly in advance of the other pull bar, falls back into line with them. Upon the selection of the Unshift or Letters combination, which uses all five selector bars, the unshift pull bar is engaged by the operating bail in the same manner as other pull bars. When this happens the trip lever is pulled out of engagement with the shift latch lever, thereby permitting the return of the platen to its lower or normal position.

16. When the end of a line is reached and it is desired to rotate the platen so as to start the printing on the next line, the line feed mechanism must be operated. The operation of this mechanism shown in Figure 7, up to and including the selection of the line feed pull bar, is the same as previously described for printing, No. 2 selector bar being operated. When the line feed pull bar is engaged by the operating bail, however, it not only throws up the line feed type bar in the usual manner but also closes the line feed contact. This contact controls the operation of the line feed solenoid. The platen which is to be rotated the distance of one line is fastened with the ratchet wheel to the platen shaft and they are both held stationary by means of the jockey roller and its spring. The line feed connecting lever and line feed bail are rigidly connected together

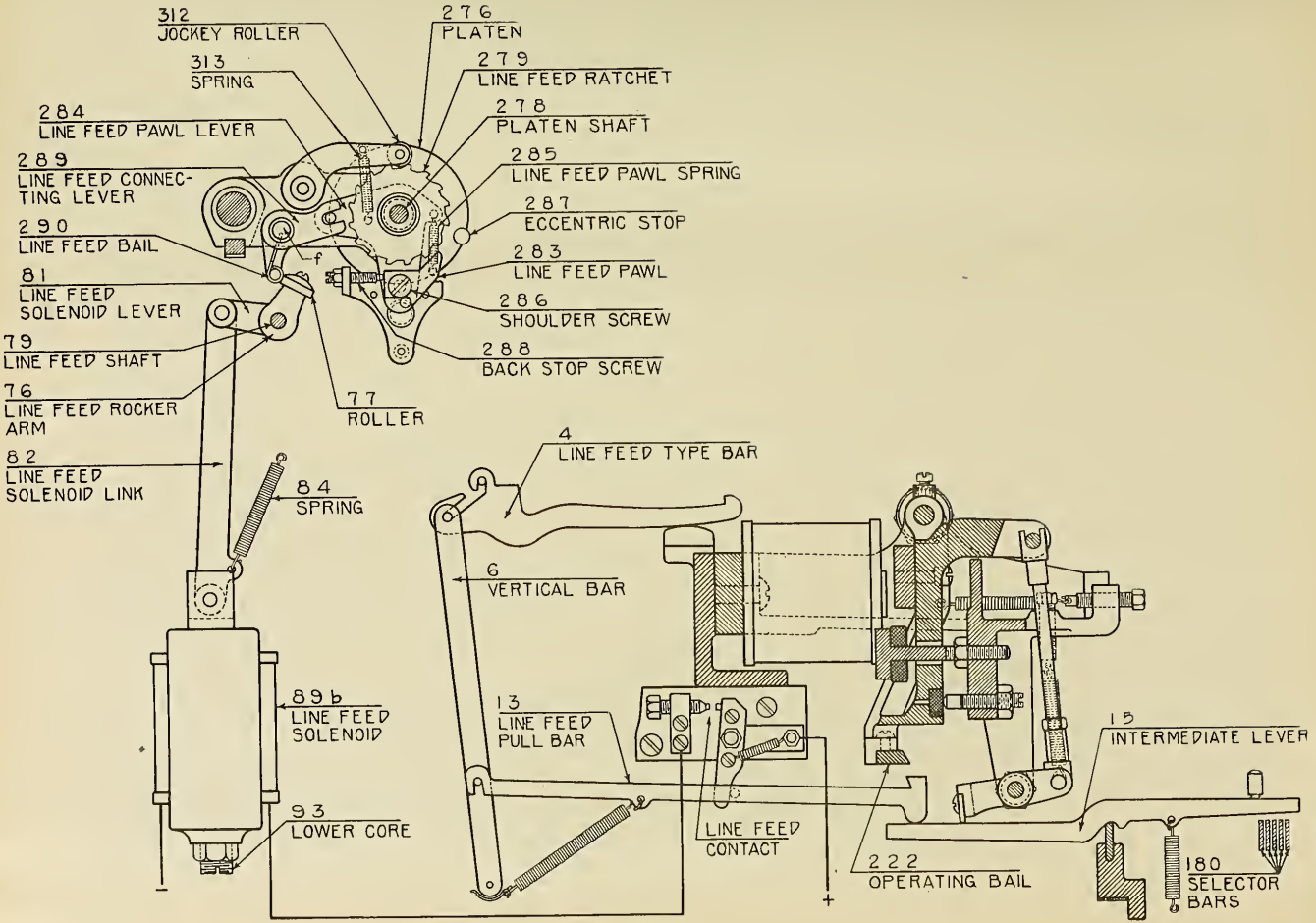

312
JOCKEY ROLLER
313
SPRING
284
LINE FEED PAWL LEVER
289
LINE FEED CONNECTING LEVER
290
LINE FEED BAIL
81
LINE FEED SOLENOID LEVER
79
LINE FEED SHAFT
76
LINE FEED ROCKER ARM
82
LINE FEED SOLENOID LINK
77
ROLLER
276
PLATEN
279
LINE FEED RATCHET
278
PLATEN SHAFT
285
LINE FEED PAWL SPRING
287
ECCENTRIC STOP
283
LINE FEED PAWL
286
SHOULDER SCREW
288
BACK STOP SCREW
f
84
SPRING
89b
LINE FEED SOLENOID
93
LOWER CORE
4
LINE FEED TYPE BAR
6
VERTICAL BAR
13
LINE FEED PULL BAR
LINE FEED CONTACT
15
INTERMEDIATE LEVER
222
OPERATING BAIL
180
SELECTOR BARS
+
-

Fig. 7

and rotate about the fixed shaft on the carriage. The line feed bail spring (not shown in drawing) on shaft f tends always to turn this shaft counter-clockwise. This tends to rotate the line feed pawl lever clockwise about the platen shaft and hold the line feed pawl against its stop screw. The line feed pawl turns on its shoulder screw which is mounted on the line feed pawl lever and its spring tends to force the end of the pawl toward the ratchet. The lever, as explained above, tends to turn clockwise, however, thereby pressing the pawl against its back stop and keeps the end of the pawl away from the ratchet. The line feed rocker arm carrying a roller is rigidly attached to the line feed shaft, as is the line feed solenoid lever. This shaft rotates in bearings on the frame. When the line feed solenoid is operated, as explained, it pulls down its plunger and, by means of the link and intermediate mechanism described, rotates the line feed pawl lever counter-clockwise. Upon the first movement of this lever the line feed pawl moves away from its back stop screw and its spring forces it to drop into a tooth on the ratchet wheel. The continuation of the rotation of the lever now allows the pawl to move the ratchet and therefore the platen. When the ratchet is moved one tooth the eccentric stop causes the ratchet to bind against the pawl, thereby preventing any overthrow of the ratchet wheel. When the line feed contact is again opened through the release of the line feed pull bar, the line feed solenoid is de-energized, and the line feed mechanism is returned to its normal position by the spring attached to the solenoid link and by the spring on the shaft f and also by the back stop screw, as described. The dummy type bar used in the line feed train is of special construction and does not operate the universal bar, but serves only to prolong the duration of contact of the line feed contact.

17. In order to start on a new line of printing it is necessary not only to shift the paper to a higher position, but it is also generally necessary to return the carriage to its right hand or "Zero" position so that the next line of printing may start at the same margin from the left edge of the paper. This is done by the carriage return mechanism.

18. The similarity of the carriage return function to the others already described lies only in the fact that, like the rest, it requires the selection of an intermediate lever which is brought about by the operation of the No. 4 selector bar. Its train of mechanism does not contain a pull bar, however, and the action of the operating magnet serves only to lift the restoring bar and allow the intermediate lever (Fig. 8) to drop into the slot previously set up by the selection of the No. 4 selector bar. When this happens the rear end of the lever is raised, thereby closing the carriage return contact. The contact screw is stationary but the spring is attached to the carriage return contact lever and is rotated with it by the intermediate lever about a fixed shoulder screw. This movable lever also carries a stud so that when the contact is closed the carriage return trip lever may hold it in this position until the operation is complete. Figure 8 is a view of the carriage return mechanism as it would be seen from the front of the printer. The upper half is shown as a front view, while the lower half is shown in perspective. The large gear wheel contains the carriage return spring (not shown in drawing), which tends to revolve this gear counter-clockwise and the small gear in mesh with it clockwise. Directly above the small gear and in mesh with it is the carriage rack (Fig. 6). The gears just mentioned revolve about the fixed centers. The shaft m, the small gear and the two equal size ratchet wheels, shown distorted for clearness, are fastened together and move as one piece. The spacing solenoid is shown at the left and the accelerating solenoid at the right. The spacing pawl lever and the accelerating lever pivot on fixed studs. When the carriage return contact is closed both solenoids draw down their plungers, but because of the difference in the position of the fulcrums the spacing pawl is raised and disengaged from the spacing ratchet and the accelerating pawl is lowered. As this letter pawl is lowered the accelerated lever also rotates the retaining pawl about its shoulder screw, thus allowing the carriage return spring mentioned above to revolve the large gear wheel and force the carriage to the right. Just after the accelerating lever lifts the retaining pawl out of engagement with its ratchet the accelerating pawl drops into a tooth on the carriage return ratchet and tends to start and accelerate the return of the carriage. Both solenoids remain operated during the return of the carriage, thereby allowing the gear wheels to rotate freely until the carriage returns to the right end of the machine. At this time the lug n on the large gear strikes a short operating

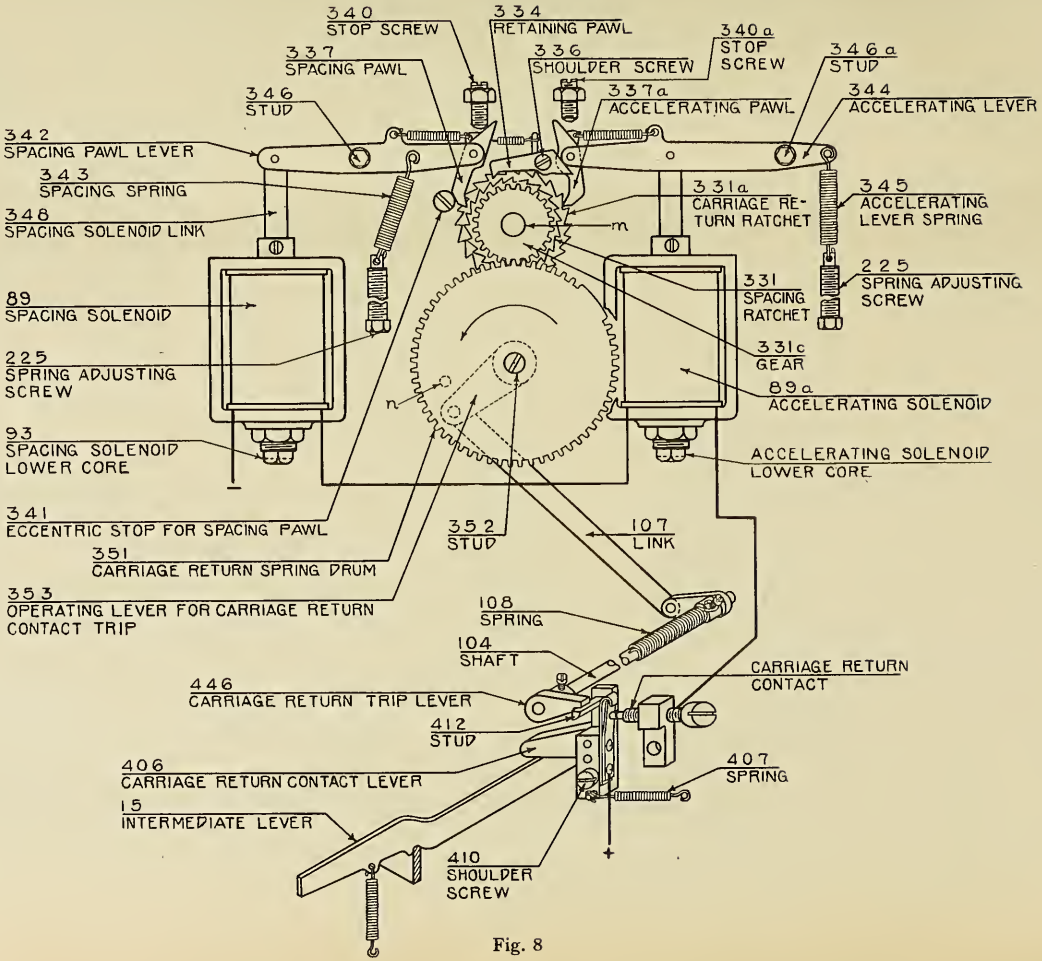

340
STOP SCREW
334
RETAINING PAWL
340a
STOP
SCREW
337
SPACING PAWL
336
SHOULDER SCREW
346a
STUD
346
STUD
337a
ACCELERATING PAWL
344
ACCELERATING LEVER
342
SPACING PAWL LEVER
343
SPACING SPRING
348
SPACING SOLENOID LINK
331a
CARRIAGE RE-
TURN RATCHET
345
ACCELERATING
LEVER SPRING
m
225
SPRING ADJUSTING
SCREW
331
SPACING
RATCHET
89
SPACING SOLENOID
331c
GEAR
225
SPRING ADJUSTING
SCREW
89a
ACCELERATING SOLENOID
n
93
SPACING SOLENOID
LOWER CORE
ACCELERATING SOLENOID
LOWER CORE
341
ECCENTRIC STOP FOR SPACING PAWL
352
STUD
107
LINK
351
CARRIAGE RETURN SPRING DRUM
353
OPERATING LEVER FOR CARRIAGE RETURN
CONTACT TRIP
108
SPRING
104
SHAFT
CARRIAGE RETURN
CONTACT
446
CARRIAGE RETURN TRIP LEVER
412
STUD
406
CARRIAGE RETURN CONTACT LEVER
407
SPRING
15
INTERMEDIATE LEVER
410
SHOULDER
SCREW

Fig. 8

lever and by means of the system of links and levers shown rotates the carriage return trip lever so that the stud on the carriage return contact lever is released, thus opening the carriage return contacts. This de-energizes the solenoids and the carriage comes to rest at the extreme right against the top of the buffer arm, which, in turn, rests against the washer on the carriage slide rod. (Not shown on Figure 8.) When the solenoid plungers are released the accelerating lever spring lifts the accelerating pawl up against its stop screw out of engagement with the carriage return ratchet and allows the retaining pawl to drop so that it again rests on the spacing ratchet. The spacing spring at the same time lowers the spacing pawl and revolves the small gear, thereby moving the carriage forward until the retaining pawl drops into the tooth next in order on the spacing ratchet. This movement of the carriage to the left a fraction of a space provides a definite Zero or starting point for the carriage and permits each new line to start with a definite margin from the left edge of the paper.

19. For signalling purposes a bell is provided on the printer which is operated whenever the signals, Figures, J, and Letters are sent to the printer. The construction of the bell mechanism as well as its operation is described in the following paragraph:

20. Extending from the front to the rear of the printer (Fig. 9) is a signal link. The rear end of this link is pivoted to a lever on the shift shaft and its front end is pivoted in a similar way to a lever on the signal shaft. The signal shaft likewise rotates in fixed bearings. A signal rod lever provided with a slot in which a signal rod may move freely from left to right, but which compels the rod to conform to the up-and-down motion of the end of the lever, is rigidly attached to the signal shaft. The right hand end of the signal rod moves in a hole in the casting p, and its motion to the right is limited by the hexagonal part, q, of the signal rod head. When the carriage is shifted to the upper case position by the Figures function, as previously described, the shift magnet operating lever is rotated. This motion is rotated in the counter-clockwise direction, thus lowering the signal rod lever, and with it the signal rod. If the letter "J" is next sent to the printer, the J intermediate lever will be selected in the usual way, thus putting the J pull bar in line to be operated by the operating bail on its back stroke. In this position the signal rod is directly in the path of the J pull bar. When the operating bail returns to the right, therefore, the pull bar hook is wedged in between the operating bail and the signal rod, as shown in dotted lines, thus forcing the signal rod to the right. The end of the rod then opens the bell contact. This contact is connected in parallel with the signal bell solenoid (Fig. 4), which in turn is in series with the spacing circuit. As the J type bar moves up the rounded part of the bar strikes the universal bar thus closing the spacing contact in the usual manner. The opening of the bell signal contact has introduced into the spacing circuit an additional impedance which limits the current that can flow in that circuit to a value so low that it will not operate the spacing solenoid, but since the bell solenoid operates on a very small current, this solenoid is operated, thus striking the bell. Although the J type bar is free to move up far enough to operate the universal bar, the limited motion of the signal rod prevents the type bar from moving up far enough to permit the type to strike the platen. It also prevents the J pull bar from releasing in the usual manner. When the Letters signal is sent to the printer the carriage is unshifted in the usual way and the signal rod is removed from its position in the path of the J pull bar, which is therefore permitted to release and drop back in its normal position. This completes the bell signal operation.

21. As indicated in Figure 5, the movement of the universal bar rotates the universal bar lever shaft and consequently the ribbon feed pawl lever which is attached thereto. This lever carries the upper and lower ribbon feed pawls. Referring to Figure 10, the left hand upper and lower pawls are connected by a link. The upper ends of these links are attached to the throwover triangle so that while the link on the left holds its pawls away from the ratchet on the left, the link on the right allows the pawls that it controls to rest on the right hand ratchet. The ribbon spools rest on the upper ends of their shafts and bevel gears are attached to the lower ends of these shafts. One bevel gear (not shown on Figure 10) is a part of the left hand ratchet and both revolve freely on the short stud indicated. The right hand ratchet and bevel gear are attached to the same shaft and revolve as one piece. So long as the printer continues to print, the universa l

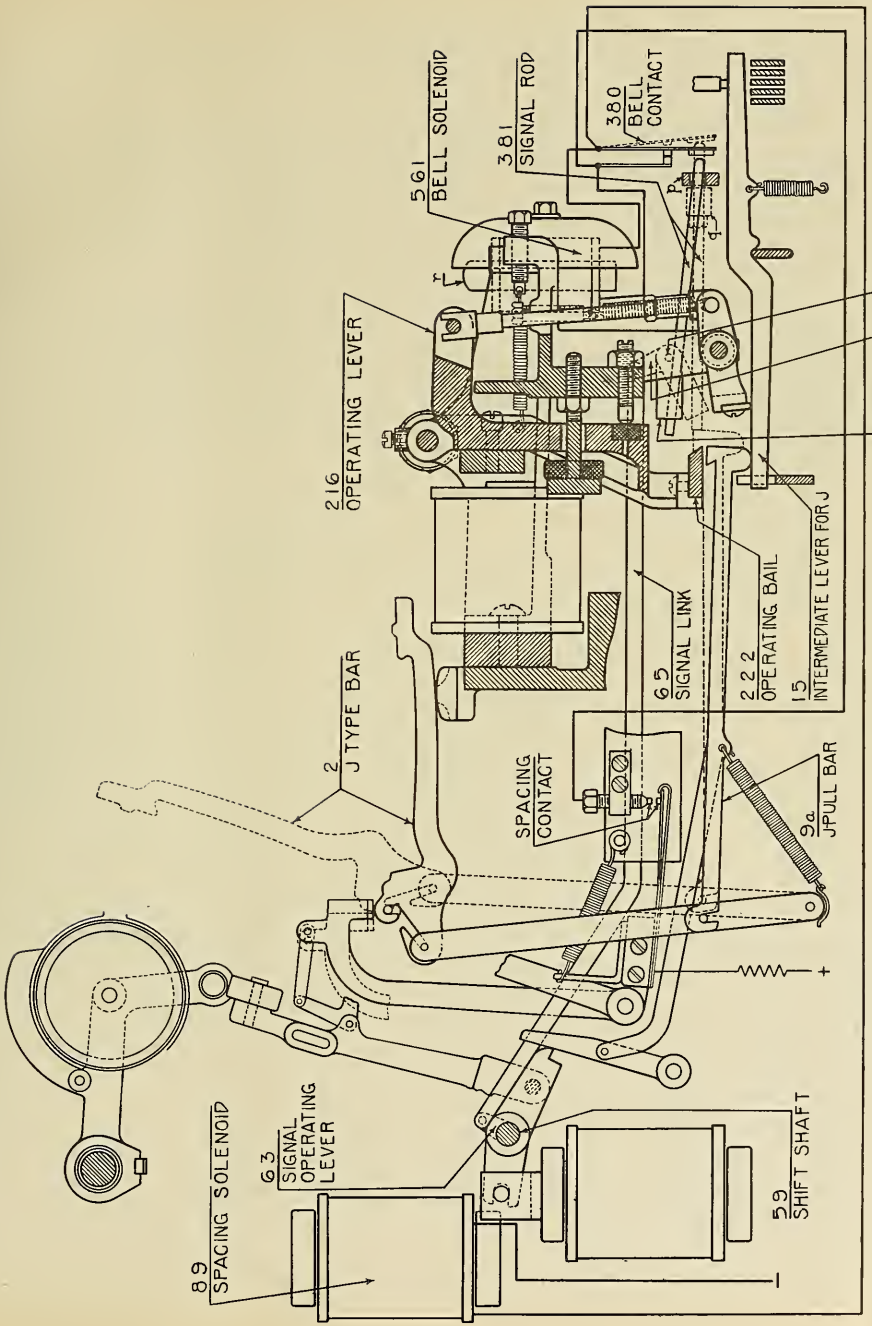

89
SPACING SOLENOID
63
SIGNAL OPERATING LEVER
59
SHIFT SHAFT
2
J TYPE BAR
SPACING CONTACT
9a
J PULL BAR
65
SIGNAL LINK
222
OPERATING BAIL
15
INTERMEDIATE LEVER FOR J
216
OPERATING LEVER
561
BELL SOLENOID
381
SIGNAL ROD
380
BELL CONTACT
242
SIGNAL ROD LEVER
106
LEVER
240
SIGNAL SHAFT
+
–

Fig. 9

bar will be moved back and forth, thereby operating the ribbon feed pawl lever (Fig. 5), the upper and lower feed pawls, the right hand ribbon feed ratchet and therefore the ribbon spool on the right hand shaft.

22. This action will continue until the ribbon, previously threaded through t and u and the ribbon shield, is all wound up on the right hand spool and the left hand spool is nearly empty. In unwinding, the left hand spool revolves its bevel gear and ratchet, but, as previously shown, the left hand set of pawls are out of engagement with their ratchet; therefore the latter is free to turn. Just as the ribbon gives out on the left side a small eyelet engages the pins at u. The eyelet is attached to the ribbon but because of its inability to pass through the slot u it moves the left ribbon feed reversing lever and changes conditions so that the left hand ratchet instead of the right is now operated and therefore the direction of the motion of the ribbon is reversed.

23. The actual reversing of the ribbon takes place as follows: When the left ribbon reversing lever is moved by the eyelet in the ribbon, the ribbon connecting lever is thrown from its rear to its front stop pins. This causes the throwover lever to rotate the throwover triangle counter-clockwise. This action lifts the right hand set of feed pawls from their ratchet and lowers the left hand set of feed pawls so that they rest on their ratchet. Further operation of the ribbon feed pawl lever will now cause the ribbon to be wound on the left spool. The right ribbon spool will be free to unwind until the ribbon again reverses.

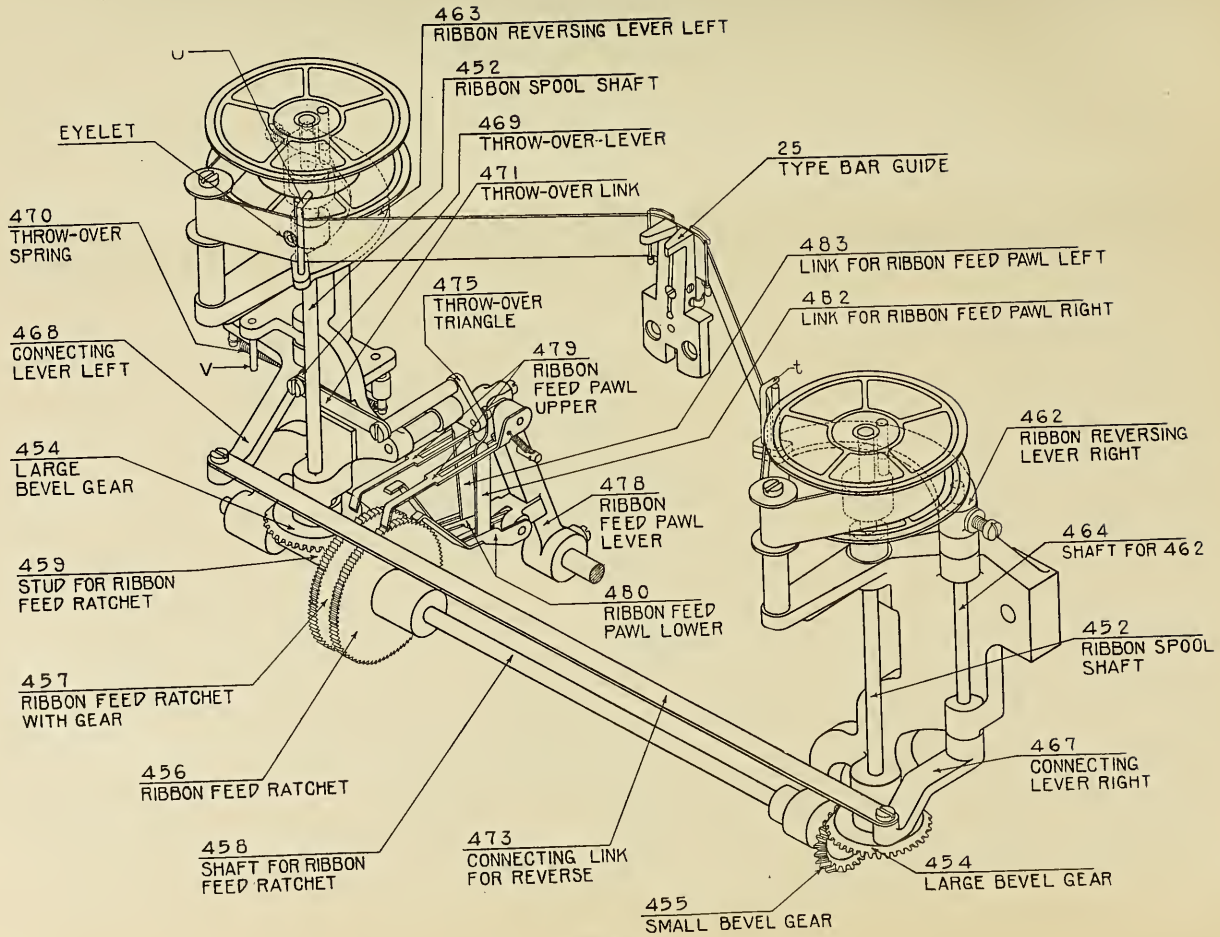

463
RIBBON REVERSING LEVER LEFT
452
RIBBON SPOOL SHAFT
469
THROW-OVER LEVER
471
THROW-OVER LINK
25
TYPE BAR GUIDE
EYELET
470
THROW-OVER SPRING
483
LINK FOR RIBBON FEED PAWL LEFT
482
LINK FOR RIBBON FEED PAWL RIGHT
475
THROW-OVER TRIANGLE
468
CONNECTING LEVER LEFT
479
RIBBON FEED PAWL UPPER
462
RIBBON REVERSING LEVER RIGHT
454
LARGE BEVEL GEAR
478
RIBBON FEED PAWL LEVER
464
SHAFT FOR 462
459
STUD FOR RIBBON FEED RATCHET
480
RIBBON FEED PAWL LOWER
452
RIBBON SPOOL SHAFT
457
RIBBON FEED RATCHET WITH GEAR
467
CONNECTING LEVER RIGHT
456
RIBBON FEED RATCHET
458
SHAFT FOR RIBBON FEED RATCHET
473
CONNECTING LINK FOR REVERSE
454
LARGE BEVEL GEAR
455
SMALL BEVEL GEAR

Fig. 10

## ADJUSTMENTS

1. **General.** Before adjusting, the printer shall be thoroughly cleaned, examined for mechanical or electrical defects, and a thin film of oil applied to all bearing surfaces.

2. **Selector Bar Springs.** Adjust the selector bar springs (Fig. 2) by means of the mounting screw which holds the block so that each spring exerts a force of between 30 and 50 grams on its corresponding selector bar.

3. **Selector Armature Stop Screw.** To adjust a selector armature upper stop screw, first loosen the clamp screw, then lower the stop screw until the armature trigger fails to hold the selector bar to the left, and then raise the latter screw one-half turn. Reset the clamp screw.

4. **Removal of Type Bars.** Referring to Figure 5 it will be seen that by pushing the universal bar back out of the way the type bar may be lifted from the fulcrum rod and pulled forward so that this rod passes through the opening in the type bar. It is then a simple matter to unhook the type bar from the rivet in the vertical bar and the bar is clear of the mechanism for cleaning or putting on new type.

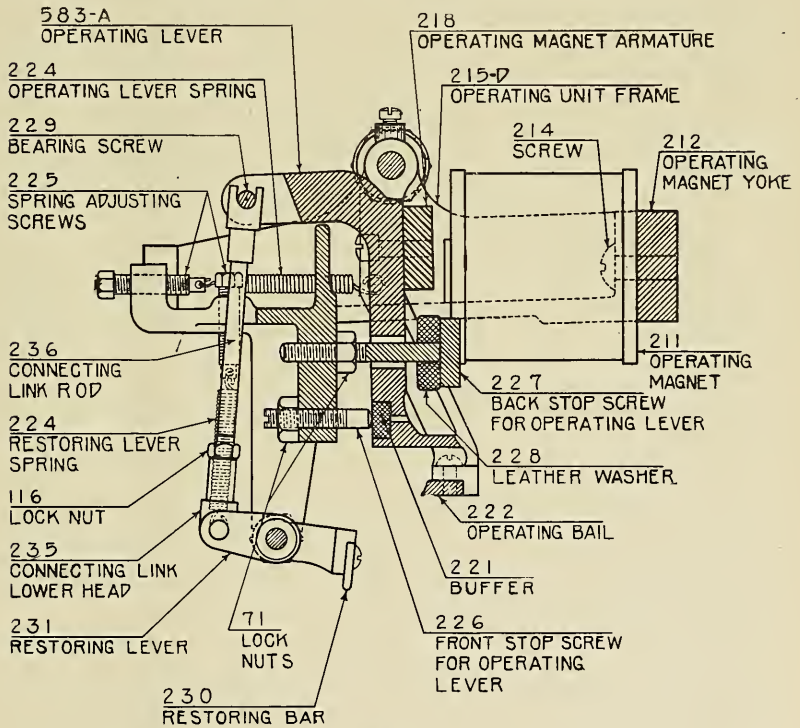



Fig. 11

5. **Type Bar Pad.** The purpose of the type bar pad is to form a rest for the type bars and its construction cuts down to a minimum the bounce of the type bars on their return strokes. If a bar bounces excessively it may get in the way of the next succeeding type bar to be operated or it may cause the second letter of a double to be light, for if a type bar is not resting on the pad when the operating bail engages with the pull bar hook the latter hook will be in a forward position, the bail will not engage it properly and the operating stroke will be impaired. This pad should be as low as possible and still perform its function. When the type bars are resting on the pad and on the fulcrum rod the rivet at the top of the vertical bar should have a slight play forward and backward. The bottom of the slots in the type bars form the back stops for the vertical bars.

6. **Operating Unit.** The operating unit (Fig. 11) consists principally of the operating magnets, and operating lever, the operating bail and the connecting link rod which operates the restoring lever and the restoring bar. The adjustment screw, in the end of the restoring bar, that lifts the operating contact lever is shown in Figure 5 in schematic form.

7. **Position of Operating Unit.** The operating unit may be adjusted higher or lower or tilted by placing liners under its various horizontal surfaces. By referring to Figure 5 it will be seen that the correct height of the operating unit, of which the operating bail is a part, depends on the height of the selector bars. Lift the restoring bar so as to allow the intermediate levers to rest on the tops of the selector bars, then adjust the height of the operating unit by means of shims or liners, as described, until the operating bail is 1/64 inch above the tops of the pull bar hooks, being careful to get the same distance all along the line. If now the restoring bar is parallel to the operating bail, as it should be, it will engage all intermediate levers at the same time and the latter will be lifted from the selector bars simultaneously. Operate the restoring bar slowly by hand and see that all intermediate levers are lifted from the selector bars at the same time. Next see that when the operating bail is in its rear position it is parallel to the ends of the pull bar hooks. If this condition does not prevail the operating lever may be bent slightly so as to make the bail parallel to the hooks. This should be necessary only when installing a new operating unit.

8. **Connecting Link Rod.** By removing the bearing screw at the top (Fig. 11) and loosening the lock nut near the lower end, the connecting link rod may be shortened or lengthened by screwing it in or out of the lower head. The length of this rod shall be such that when the operating bail (Fig. 5) engages with a selected pull bar the restoring bar engages with the corresponding intermediate lever at the same time. If the rod is too short the restoring bar will lower the selected intermediate lever and therefore the corresponding pull bar hook before the operating bail engages with it properly. If, on the other hand, the rod is too long the restoring bar will delay its function of lifting the intermediate levers from the selector bars and the selector bars will therefore be late in resetting.

9. **Restoring and Operating Lever Springs.** Adjust the restoring lever springs (Figs. 5 and 11) by means of the adjusting screws until they are strong enough to overcome the combined tension of all of the intermediate lever springs (Fig. 5). When all of the intermediate levers are pressed against the selector bars by hand the tension of the restoring lever springs shall be enough to lift them off again when the pressure of the hand is released. They shall be as weak as possible consistent with the foregoing condition. The operating lever springs shall be adjusted so that the print is clear and sharp, care being taken not to get them stronger than necessary.

10. **Upper Stop for Intermediate Levers.** The upper stop for intermediate levers (Fig. 5) contains slotted holes, thereby allowing up and down adjustment. Set this piece so that there is a space of .015 inch between the tops of the selector bars and the bottom of the intermediate levers when the latter are resting against the stop.

11. **Rear Stop for Operating Lever.** The rear stop screw for the operating lever threads into the operating unit frame and extends through a hole in the operating lever.

The under side of the head of this screw is padded by a leather washer. Fix this stop screw by means of its lock nut so that there will be 1/32 inch between the operating bail (Fig. 5) and the ends of the pull bar hooks when the operating lever is held against it.

12. **Front Stop for Operating Lever.** The front stop screw for the operating lever shall be so set and locked that when the operating bail is resting against it any pull bar should drop off the operating bail, when the type on the corresponding type bar is 1/2 inch from the platen.

13. **Position of Operating Magnet.** Figure 11 shows the operating magnet yoke fastened to the operating unit frame. By loosening the yoke mounting screws and inserting shims or liners between the yoke and the frame the position of the operating magnet may be varied. Adjust its position so that there is a space of at least .005 inch between the magnet cores and the armature on the operating lever when the latter is held against the rear stop screw. The armature must not touch the magnet cores.

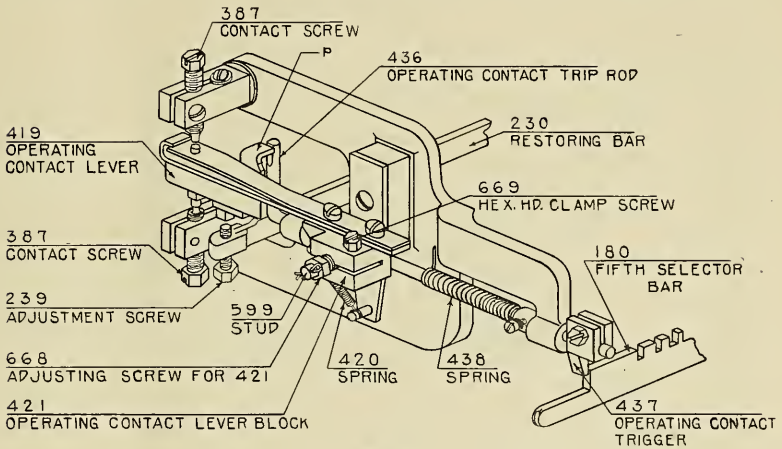



Fig. 12

14. **Operating Contact Lever Block.** The adjustable bearing for the operating contact lever block (Fig. 12) shall be so set in the block that there will be a minimum amount of end play on the stud. The clamp screw affords a means of locking the block when this screw has been correctly located.

15. **Upper and Lower Contact Screws.** While the operating contact lever is in its upper position, adjust the lower or operating contact screw so that the gap is 1/32 inch and set the upper or reset contact spring .003 inch.

16. **Restoring Lever Adjustment Screw.** Set the adjustment screw (Figs. 5 and 12) on the left hand end of restoring bar low enough so that the reset contacts do not close until the operating bail clears the shortest pull bar hook and high enough so that it will lift the operating contact lever sufficiently to allow the end of the trip rod to spring under the catch and hold the reset contacts closed.

17. **Operating Contact Trigger.** Adjust the position of the trigger on the trip rod so that the end of the rod will spring under the catch on the contact lever as far as possible with the No. 5 selector bar unoperated and so that when the armature of the reset magnet is operated slowly by hand the contact lever will be released.

18. **Trip Rod Spring.** The tension of the spring tending to turn the trip rod in a counter-clockwise direction shall be such that a force of between 50 and 75 grams, applied to the upper end of the rod, is required to balance it.

19. **Position of Universal Bar.** The universal bar should be parallel to the type bar segment. If two end type bars are raised at the same time they should both engage the universal bar while at the same distance from the platen. If this condition does not exist the lever which supports the universal bar lever arm may be twisted slightly. This never should be necessary except in the replacements of parts. When the universal bar is in its backward or operated position, both the spacing contact lever spring and the flat spacing contact spring (Fig. 5) tend to return it to its forward or normal position.

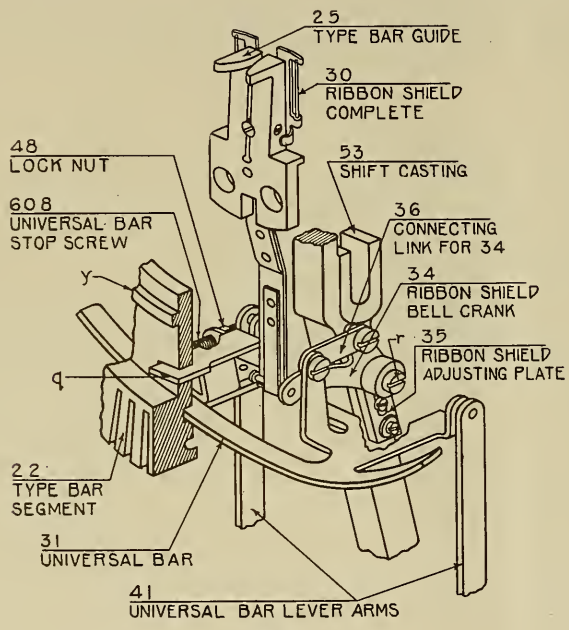



Fig. 13

20. **Terminal Bar Stop Screw.** The projection q (Fig. 13) is part of the universal bar and keeps the latter from being raised by the type bars. On this projection and back of the type bar segment is a stop screw that limits the forward position of the universal bar. Adjust this screw so that when the T type bar is raised and starts to force back the universal bar there shall be a space of between 1 1/8 to 1 1/4 inches between the bottom type on the end of the type bar and the back of the type bar guide.

21. **Purpose of Ribbon Shield.** Figure 13 serves to show the ribbon shield and its action. The function of the ribbon shield is to form a guide for the ribbon, to lift it in the path of the type during the printing operation, and lower it out of the way so as to make the printing visible when the type bars are at rest.

22. **Adjustment of Ribbon Shield.** In Figure 13, r is a fixed point on the shift casting. When the universal bar is pushed back by a type bar a link causes the bell crank to turn clockwise, and lift the ribbon shield, and therefore the ribbon, so that the latter is between

the type and the paper when the type hits it. The proper initial position of the ribbon shield may be obtained by varying the position of the point r. This point r is carried on an adjustable plate. Set this plate so that the printing occurs on the upper half of the ribbon.

**23. Removal of Ribbon Shield.** The ribbon shield hooks over a small pin on the bell crank and it is held there by a spring on the lower end of the shield, so that to remove it necessitates merely inserting a small tool through a hole in the segment to push back the lower end of the shield, thereby opening the spring and allowing it to be lifted from the machine. The hole in the type bar segment is about opposite the tops of the spring on the ribbon shield.

**24. Spacing Contact and Spacing Contact Lever Spring.** The spacing contact spring (Fig. 5) shall be strong enough so that a force of between 140 and 160 grams applied at the contact is required to depress it. With a gap of 1/64 inch between the contact points, the spacing contact lever spring shall have such a tension that a force of between 40 and 45 grams is required to push the T type until it touches the ribbon.

**25. Position of Spacing Unit.** The spacing unit (Fig. 8) is attached to the back of the printer by means of the screws through slotted holes in the spacing unit casting. Adjust the height of the spacing unit so that the pinion gear on the unit and the rack on the carriage mesh well but do not bind.

**26. Spacing Pawl Eccentric Stop Screw.** The eccentric stop screw for the spacing pawl (Fig. 8) shall be locked in position by its lock nut so that it stops the spacing pawl just as the retaining pawl drops into a tooth on the spacing ratchet wheel. In this position the ratchet wheels should remain motionless when an attempt is made to rotate them in either direction.

**27. Spacing Solenoid Lower Core.** Adjust the lower core of the solenoid so that the spacing plunger may move sufficiently to allow the spacing pawl to move up a distance equal to between a one and one-quarter and one and one-half teeth on the spacing ratchet.

**28. Spacing Pawl Upper Stop Screw.** While the plunger is held down adjust the spacing pawl upper stop screw so that it holds the spacing pawl just clear of the spacing ratchet wheel.

**29. Spacing Spring.** The spacing spring shall be adjusted strong enough to space the carriage when a force of 200 grams is applied to hold the carriage back, and it shall not be strong enough to space the carriage when a force of 300 grams is applied in the same way.

**30. Accelerating Solenoid Lower Core.** The mechanism on the left side of the spacing unit (Fig. 8) spaces the carriage forward after each character is printed. The mechanism on the right, called the accelerating mechanism, through the operation of the accelerating lever aids the carriage to return quickly. Both the spacing and accelerating solenoids are operated during the carriage return function. The accelerating solenoid lower core should be as low as possible, care being taken not to allow the accelerating lever to touch the ratchet wheels.

**31. Accelerating Lever Spring.** The tension on the accelerating lever spring shall be adjusted so that a force of between 200 and 300 grams is required at the accelerating plunger to start it downward.

**32. Accelerating Pawl Stop Screw.** When the accelerating plunger operates the accelerating lever, the latter lifts the retaining pawl and at the same time operates the accelerating pawl. Fix the height of the accelerating pawl stop screw so that the accelerating pawl will not engage the carriage return ratchet wheel until the retaining pawl is clear of the spacing ratchet.

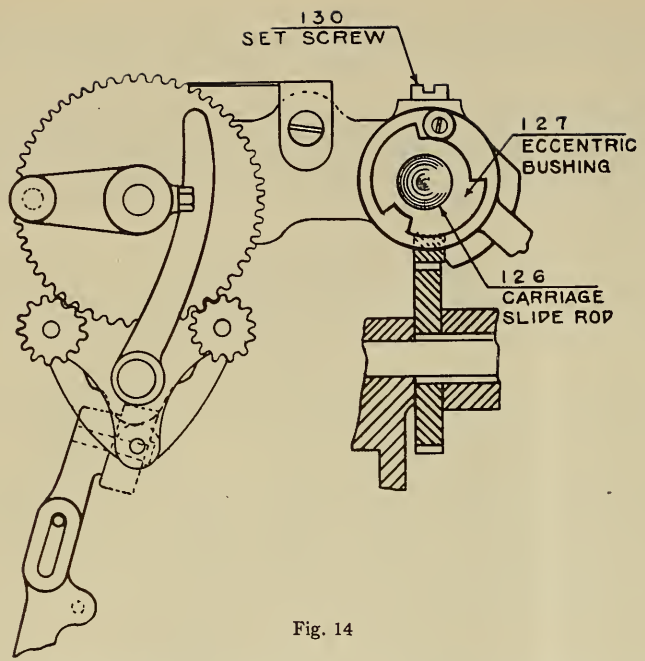



Fig. 14

33. **Zero Carriage Position.** Remove the carriage and then depress both spacing and accelerating solenoid plungers at the same time so that the gears revolve until they are stopped by the dead portion of the carriage return spring drum (Fig. 8). Then operate the spacing mechanism once. Replace the carriage in its right hand or Zero position, push the slide rod (Fig. 14) through the carriage and tighten the set screws. This insures a uniform setting of the carriage and makes sure that the carriage is stopped by the upper end of the buffer arm, which in turn rests against the leather washer on the slide rod and not by the dead portion of the spring drum. See that the leather washer on the slide rod is of such thickness that when the carriage is held against the buffer arm and the spacing solenoid plunger is held down, the end of the spacing pawl is opposite a point midway between the ends of two teeth on the spacing ratchet. If the carriage is to have a definite or Zero starting point it is obvious that the spacing pawl must engage the same tooth on the spacing ratchet at the end of each carrige return function. Figure 14 shows the eccentric bushings whereby the carriage may be shifted nearer the printing point or farther away from it. When any type bar is held firmly on the fulcrum rod (Fig. 5) and against the ring on the type bar segment the type on that bar should just touch the platen.

34. **Carriage Return Spring.** The outside end of a clock spring for returning the carriage is fastened to the inside of the hollow carriage return drum (Fig. 8). The inside end is fastened to the center stud to which is also attached a ratchet spring drum immediately behind the spring drum shown in Figure 6. To wind up the spring requires merely turning the center stud clockwise with a screw driver. To unwind the spring oscillate the escapement lever engaging the teeth of the ratchet. Adjust the tension of the carriage return spring so that the carriage will be returned from the end of a full line fast enough to be ready for the first letter on a new line while the printer is printing

at the rate of 60 words per minute, the time between the end of one full line and the beginning of a new line being that required to transmit the carriage return and line feed code combination in this sequence. Care shall be taken to eliminate all excess friction in the mechanism. In no case shall the carriage return spring be tight enough to prevent a force of 800 grams from starting the carriage to the left from its right hand position when the spacing pawl is held out of the way by closing the spacing contact.

35. **Carriage Return Trip Lever.** Adjust the carriage return trip lever (Fig. 8) so that it will be tripped just as the carriage reaches its Zero point. When the carriage is in its normal or Zero position the carriage return trip lever should allow the contact to be opened and closed without interference. When the carriage is shifted forward one space, however, and the carriage return contact lever is operated, the trip lever should hold it operated until the Zero position of the carriage is again reached.

36. **Carriage Return Contact Screw.** Adjust the contact screw so that it depresses the contact spring 3/64 inch when the contact is held closed by the trip lever.

37. **Carriage Return Contact Trip Shaft Spring.** The torsion of the spring on the shaft trip lever tending to turn that shaft clockwise shall be such that a force of between 100 and 150 grams applied at the end of the trip lever is required to balance it.

38. **Vent Screw Adjustment.** Adjust the vent screw in the carriage buffer cylinder so that the carriage will not jar the printer nor rebound when it returns from a full line of printing. Too small an opening will cause the return of the carriage to be sluggish, especially when returning from a short line. A lock nut is provided to lock the vent screw when the proper setting has been determined.

39. **Line Feed Solenoid Lower Core and Line Feed Pawl Stop Screw.** Referring to Figure 7 adjust the lower core on the line feed solenoid so that the plunger is stopped when the line feed pawl is at the end of its stroke and the jockey roller is seated between two teeth. In this position adjust the eccentric screw so that it just touches the line feed pawl. When the line feed solenoid plunger is held down the carriage should resist turning in either direction. When everything is normal the line feed pawl back stop screw should hold the line feed pawl clear of the ratchet.

40. **Line Feed Pawl Back Stop Screw.** The line feed bail spring, on the shaft f, shall be as weak as possible and still have tension enough to hold the line feed pawl away from the ratchet when the pawl is resting against its back stop screw. The latter screw shall strike as high up on the back of the pawl as possible, thereby allowing the line feed pawl spring to be strong, even though the line feed bar spring on shaft f is weak.

41. **Line Feed Contact.** The line feed contact shall close when the line feed type bar is one-third of its distance from the pad to the platen.

42. **Upper and Lower Case Printing Alignment.** To make the adjustments on the shift mechanism first loosen the clamp screw on the shift solenoid lever (Fig. 6). After the stop screw which engages with the shift casting is set so that the lower case letters strike in the center of the platen and are neither light on the bottom or top, adjust the position of the shift latch lever so that when the carriage is in its upper position and the letters trip lever is firmly under the shift latch lever the numerals will be on the same line as the letters.

43. **Unshift Pull Bar Extension.** Set the unshift pull bar extension so that the unshift pull bar is on a line with the rest of the pull bars when the letters trip lever is under the shift latch lever.

44. **Shift Solenoid Lever.** While the mechanism is in this position and the shift solenoid plunger is held against the shift solenoid lower core, lock the shift solenoid lever to the shift shaft. Make sure that the shift solenoid lower core is high enough so that the solenoid lever does not strike the solenoid frame.

45. **Shift Contact Screw.** Adjust the shift contact screw (Fig. 6) so that the shift contacts will close when the shift type bar is one-third of its way from the type bar pad to the platen.

46. **Unshift Lock Lever.** Set the attachment on the unshift lock lever so that the lip at the end of this attachment projects 1/16 inch under the extension on the shift vertical bar. Then fasten the lock lever to the shift shaft so that the lip of the attachment has full bearing on the extension on the vertical bar and just touches it when the carriage is in the unshifted position.

47. **Bell Adjustment.** No oil shall be used on the bell plunger r (Fig. 9). Adjust the signal rod so that it normally touches the signal shaft and so that it is in the path of the J pull bar when the carriage is in its shifted position. While in the latter position adjust its length so that when the J selection (selector bars 1, 2 and 4) is made and the operating lever is operated slowly by hand the J pull bar will move the bell rod sufficiently to open the bell contacts, but not sufficiently to close the spacing contact. In this way the overthrow of the universal bar will close the spacing contact and ring the bell.

48. **Ribbon Feed Pawl Lever.** Adjust the position of the ribbon feed pawl lever on the universal bar shaft (Figs. 5 and 10) so that when the space type bar is moved slowly up to the platen and back the ribbon feed pawl will move one of the ratchet wheels forward one tooth. When the ribbon reversing levers are moved slowly one set of pawls shall be lifted from one ratchet wheel before the other set drops on the other ratchet wheel. At no time shall both sets of pawls rest on the ratchet wheels.

49. **Type Bar Guide.** The type bar guide (Fig. 10) is provided with an adjustment for varying the opening of the prongs. This opening shall be made so that the type bars can enter and fall away without friction and undue vibration. It should not be necessary to change this adjustment except at wide intervals.

50. **Sixth Pulse Relay.** The sixth pulse relay contact points shall be adjusted to a normal opening of from .010 inch to .015 inch and require a force of 60 to 80 grams applied at this contact end of the armature to close the contact points.

51. Adjustment of springs not otherwise specified:

| Name of Spring | Conditions for Testing Adjustment | Force in Grams Max. | Min. |
|---|---|---|---|
| Intermediate Lever and Pull Bar Springs | Upward pull at forward end of intermediate lever with restoring bar held out of way | 25 | 15 |
| Reset Contact Spring | Downward push at Contact | 150 | 100 |
| Operating Contact Lever Spring | Upward pull where screw on left end of restoring bar strikes | 150 | 125 |
| Spacing Contact Spring | Downward push at contact | 160 | 140 |
| Ribbon Feed Pawl Spring | Force to stretch to 3/4 inch length | 50 | 35 |
| Ribbon Feed Throwover Spring | Force to stretch to 2 inch length | 250 | 150 |
| Shift Contact Lever Spring | Push at contact | 50 | 35 |
| Line Feed Contact Spring | Push at contact | 50 | 35 |
| Spacing Pawl Spring | Force to stretch to 7/8 inch length | 120 | 90 |
| Accelerating Pawl Spring | Force to stretch to 1 1/16 inch length | 75 | 50 |
| Carriage Return Contact Spring | Push at contact | 50 | 30 |
| Carriage Return Contact Lever Spring | Push at stud | 40 | 30 |
| Bell Contact Spring | Push at contact | 200 | 100 |
| Line Feed Link Spring | Push to start plunger down | 150 | 100 |
| Jockey Roller Spring | Upward pull at roller | 900 | 700 |
| Line Feed Pawl Spring | Force to stretch to 3/4 inch length | 50 | 40 |
| Pressure Roller Spring | Pull perpendicular to platen at pressure roller shaft, either end | 600 | 400 |

52. For convenience in wiring printers and relay banks in which the cable forms must be replaced, Figures 15 and 16, which show these cable forms, are included.

In Section 5-B the construction, operation and adjustment of the present (new style) 3-A Printer operating unit is described.

Many of the 3-A Printers now in the field are equipped with the old style operating units. It has been decided to make no general installation of the new style units because these parts represent a comparatively costly part of the printer and further because the majority of the old units now in service are still in good operating condition.

The only adjustment for the old style unit which is not common to the new style operating unit is the position of the striking screw, Figure 11-A, in the operating magnet armature casting. After the rear and front stop screws for the operating lever have been properly set (as specified in paragraphs 11 and 12 respectively of Section 5-B—Adjustments) the striking screw should be raised as far as possible, still permitting the operating bail to be driven to its extreme rear position when the operating magnet armature casting is depressed by hand. This adjustment will allow a slight clearance between the end of the striking screw and the stop post in the operating lever casting, thus permitting the armature to advance a part of its travel toward the pole pieces of the operating magnets before the spring load is applied. The above described adjustment is consistent with the fastest operating condition.

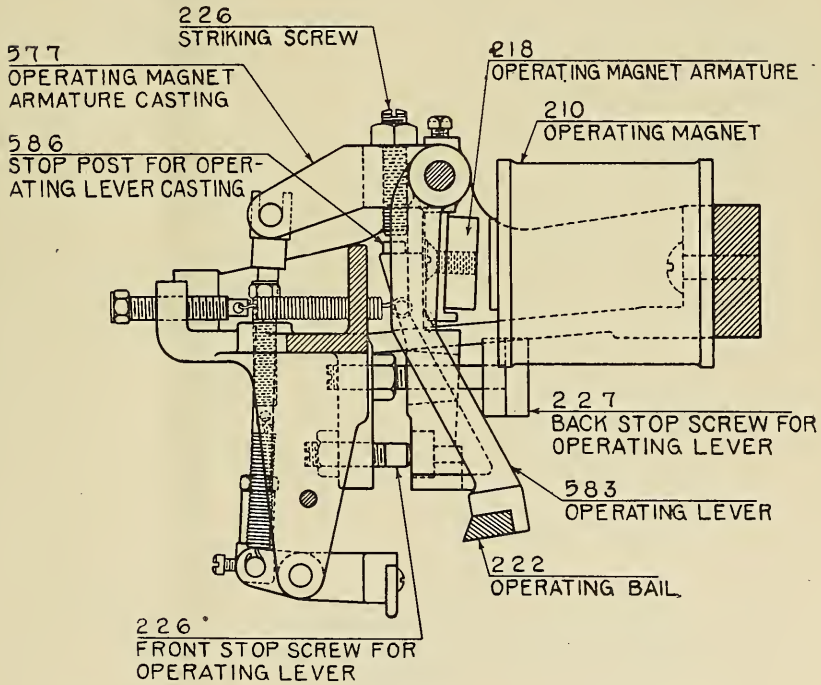



Fig. 11-A

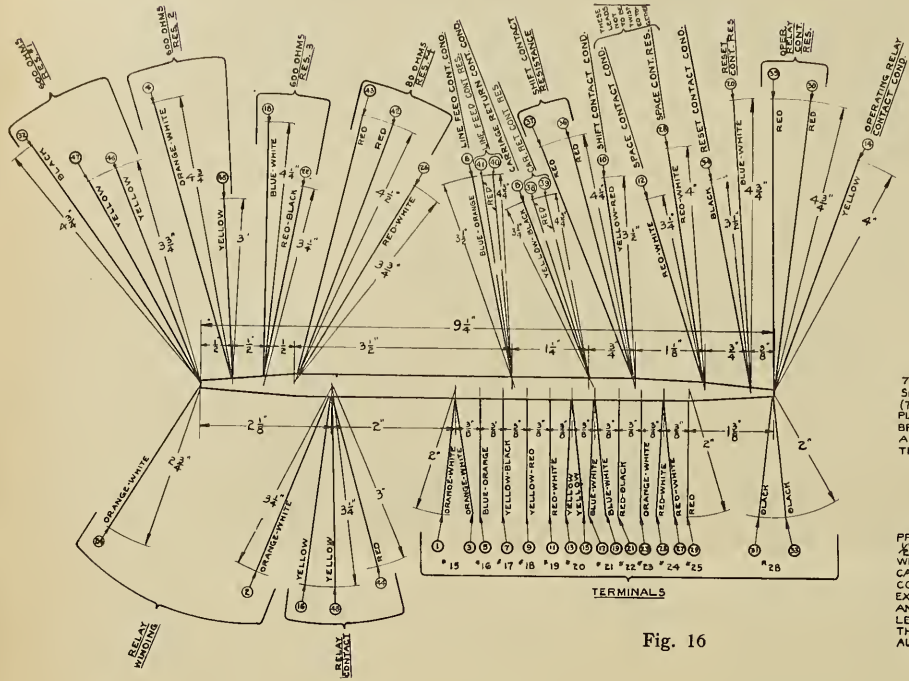



Fig. 16

| WIRING CHART | | | |
|---|---|---|---|
| WIRE NO. | COLOR | WIRE LENGTH | REMARKS |
| 1 TO 2 | ORANGE-WHITE | 8" | FROM TERM #15 TO RELAY WINDING |
| 3 TO 4 | " " | 11" | " " " " RESISTANCE #2 |
| 5 TO 6 | BLUE-ORANGE | 6" | " TERM #16 TO LINE FEED CONT COND |
| 7 TO 8 | YELLOW-BLACK | 7" | " " #17 " CAR. REV. " " |
| 9 TO 10 | YELLOW-RED | 8" | " " #18 " SHIFT CONT. COND. |
| 11 TO 12 | RED-WHITE | 8" | " " #19 " SPACE " " |
| 13 TO 14 | YELLOW | 10" | " TERM #20 TO OPER. RELAY CONT COND |
| 15 TO 16 | " | 10" | " " " " RELAY CONTACT |
| 17 TO 18 | BLUE-WHITE | 12" | " " #21 " RESISTANCE #3 |
| 19 TO 20 | " " | 10" | " " " " RESET CONT RES |
| 21 TO 22 | RED-BLACK | 11" | " " #22 " RESISTANCE #3 |
| 23 TO 24 | ORANGE-WHITE | 12" | " #23 " RELAY WINDING |
| 25 TO 26 | RED-WHITE | 12" | " " #24 " RESISTANCE #4 |
| 27 TO 28 | " " | 9" | " " " " SPACE CONT. RES |
| 29 TO 30 | RED | 9" | " " #25 " OPER RELAY CONT RES |
| 31 TO 32 | BLACK | 18" | " " #28 " RESISTANCE #1 |
| 33 TO 34 | " | 6" | " " " " RESET CONT. COND |
| 35 TO 36 | RED | 12" | " RELAY CONT. RES. TO SHIFT C. RES. |
| 37 TO 38 | " | 10" | " SHIFT CONT RES. TO C.R.G. RES. |
| 39 TO 40 | " | 11" | " C.R.CONT RES. TO L.F. CONT. RES. |
| 41 TO 42 | " | 13" | " L.F. CONT. TO 80 OHM RES. #4 |
| 43 TO 44 | " | 8" | " RESISTANCE #4 TO RELAY CONT |
| 45 TO 46 | YELLOW | 8" | " " #2 " RES. #1 |
| 47 TO 48 | " | 10" | " " #1 " RELAY CONT. |

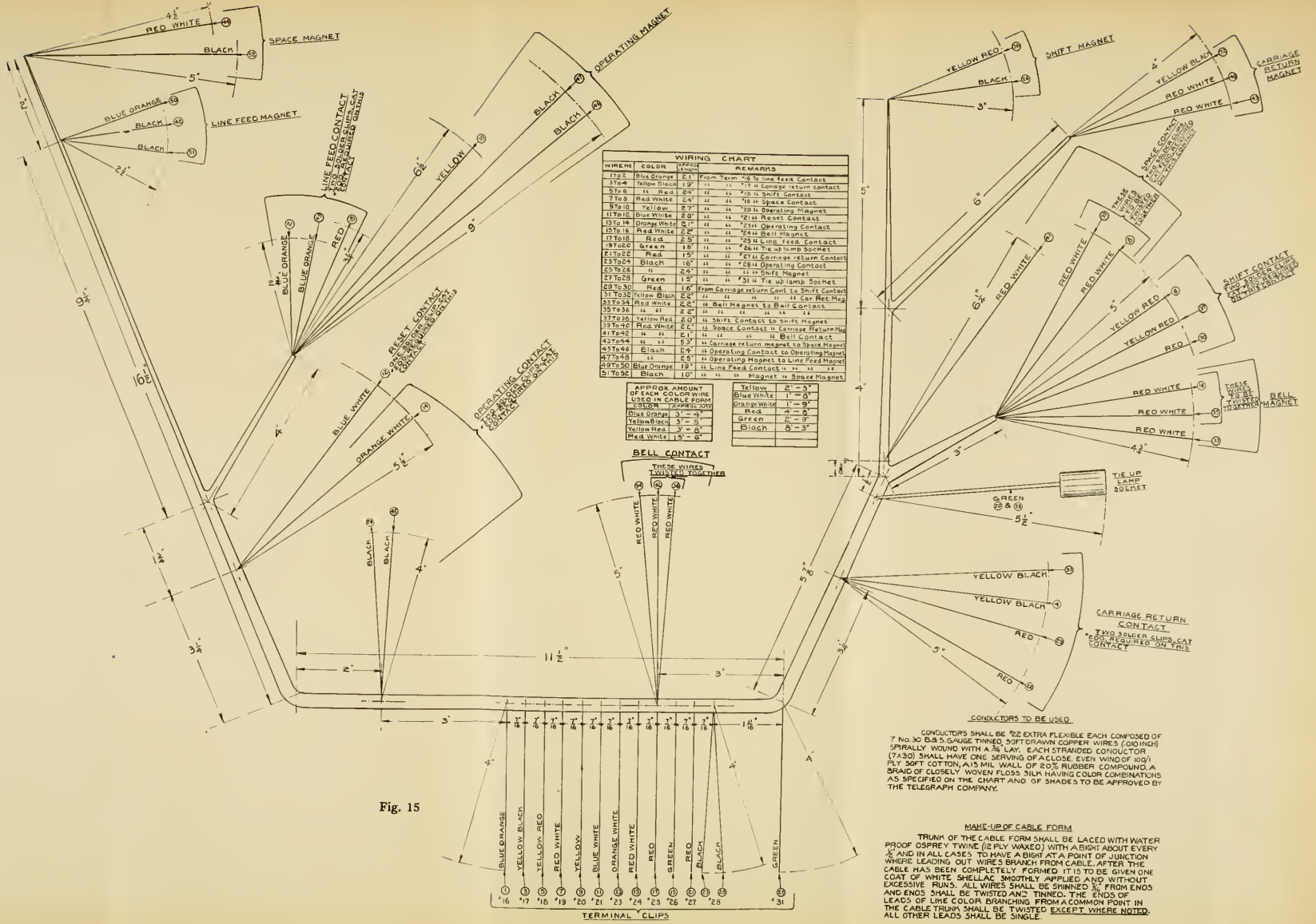
| APPROX. AMOUNT OF EACH COLOR WIRE USED IN CABLE FORM | |
|---|---|
| COLOR | APPROX AMT. |
| ORANGE-WHITE | 2'-7" |
| BLUE-ORANGE | 6" |
| YELLOW-BLACK | 7" |
| YELLOW-RED | 8" |
| RED-WHITE | 2'-3" |
| YELLOW | 3'-2" |
| BLUE-WHITE | 1'-10" |
| RED-BLACK | 11" |
| RED | 5'-9" |
| BLACK | 1'-10" |

## CONDUCTORS TO BE USED

CONDUCTORS SHALL BE #22 EXTRA FLEXIBLE EACH COMPOSED OF 7 No. 30 B.& S. GAUGE TINNED, SOFT DRAWN COPPER WIRES (.010 INCH) SPIRALLY WOUND WITH A 3/4" LAY. EACH STRANDED CONDUCTOR (TX 30) SHALL HAVE ONE SERVING OF A CLOSE, EVEN WIND OF 100/1 PLY SOFT COTTON, A 15 MIL. WALL OF 20% RUBBER COMPOUND, A BRAID OF CLOSELY WOVEN FLOSS SILK HAVING COLOR COMBINATIONS AS SPECIFIED ON THE CHART AND OF SHADES TO BE APPROVED BY THE TELEGRAPH COMPANY.

## MAKE-UP OF CABLE FORM

TRUNK OF THE CABLE FORM SHALL BE LACED WITH WATER PROOF OSPREY TWINE (12 PLY WAXED) WITH A BIGHT ABOUT EVERY 6" AND IN ALL CASES TO HAVE A BIGHT AT A POINT OF JUNCTION WHERE LEADING OUT WIRES BRANCH FROM CABLE. AFTER THE CABLE HAS BEEN COMPLETELY FORMED IT IS TO BE GIVEN ONE COAT OF WHITE SHELLAC SMOOTHLY APPLIED AND WITHOUT EXCESSIVE RUNS. ALL WIRES SHALL BE SKINNED 1/16" FROM ENDS AND ENDS SHALL BE TWISTED AND TINNED. THE ENDS OF LEADS OF LIKE COLOR BRANCHING FROM A COMMON POINT IN THE CABLE TRUNK SHALL BE TWISTED EXCERT WHERE NOTED. ALL OTHER LEADS SHALL BE SINGLE.




WIRING CHART

| WIRE No. | COLOR | APPROX LENGTH | REMARKS |
|---|---|---|---|
| 1 To 2 | Blue Orange | 2'-1" | From Term #16 to line feed Contact |
| 3 To 4 | Yellow Black | 1'-3" | " " " #17 " Carriage return contact |
| 5 To 6 | " Red | 2'-4" | " " " #19 " Shift Contact |
| 7 To 8 | Red White | 2'-4" | " " " #18 " Space Contact |
| 9 To 10 | Yellow | 2'-7" | " " " #20 " Operating Magnet |
| 11 To 12 | Blue White | 2'-0" | " " " #21 " Reset Contact |
| 13 To 14 | Orange White | 2'-1" | " " " #23 " Operating Contact |
| 15 To 16 | Red White | 2'-2" | " " " #24 " Bell Magnet |
| 17 To 18 | Red | 2'-5" | " " " #25 " Line Feed Contact |
| 19 To 20 | Green | 1'-8" | " " " " " " |
| 21 To 22 | Red | 1'-5" | " " " #26 " Tie up lamp Socket |
| 23 To 24 | Black | 1'-8" | " " " #27 " Carriage return Contact |
| 25 To 26 | " | 2'-4" | " " " #28 " Operating Contact |
| 27 To 28 | Green | 1'-5" | " " " " " Shift Magnet |
| 29 To 30 | Red | 1'-6" | " " " #31 " Tie up lamp Socket |
| 31 To 32 | Yellow Black | 2'-2" | From Carriage return Cont. to Shift Contact |
| 33 To 34 | Red White | 2'-2" | " " " " " " Car Ret. Mag. |
| 35 To 36 | " " | 2'-2" | " Bell Magnet to Bell Contact |
| 37 To 38 | Yellow Red | 2'-0" | " " " " " " |
| 39 To 40 | Red White | 2'-2" | " Shift Contact to Shift Magnet |
| 41 To 42 | " " | 2'-1" | " Space Contact " Carriage Return Mag |
| 43 To 44 | " " | 5'-3" | " " " " Bell Contact |
| 45 To 46 | Black | 2'-4" | " Carriage return magnet to Space Magnet |
| 47 To 48 | " | 2'-5" | " Operating Contact to Operating Magnet |
| 49 To 50 | Blue Orange | 1'-9" | " Operating Magnet to Line Feed Magnet |
| 51 To 52 | Black | 1'-0" | " Line Feed Contact " " " " |
| | | | " " " Magnet " Space Magnet |

APPROX AMOUNT OF EACH COLOR WIRE USED IN CABLE FORM

| COLOR | APPROX AMT |
|---|---|
| Blue Orange | 3'-9" |
| Yellow Black | 3'-5" |
| Yellow Red | 3'-8" |
| Red White | 15'-6" |
| Yellow | 2'-5" |
| Blue White | 1'-8" |
| Orange White | 1'-9" |
| Red | 4'-8" |
| Green | 2'-9" |
| Black | 8'-3" |

Fig. 15

CONDUCTORS TO BE USED

CONDUCTORS SHALL BE #22 EXTRA FLEXIBLE EACH COMPOSED OF 7 No.30 B.& S.GAUGE TINNED, SOFT DRAWN COPPER WIRES (.010 INCH) SPIRALLY WOUND WITH A 3/8" LAY. EACH STRANDED CONDUCTOR (7X30) SHALL HAVE ONE SERVING OF A CLOSE, EVEN WIND OF 100/1 PLY SOFT COTTON, A 15 MIL WALL OF 20% RUBBER COMPOUND, A BRAID OF CLOSELY WOVEN FLOSS SILK HAVING COLOR COMBINATIONS AS SPECIFIED ON THE CHART AND OF SHADES TO BE APPROVED BY THE TELEGRAPH COMPANY.

MAKE-UP OF CABLE FORM

TRUNK OF THE CABLE FORM SHALL BE LACED WITH WATER PROOF OSPREY TWINE (12 PLY WAXED) WITH A BIGHT ABOUT EVERY 6" AND IN ALL CASES TO HAVE A BIGHT AT A POINT OF JUNCTION WHERE LEADING OUT WIRES BRANCH FROM CABLE. AFTER THE CABLE HAS BEEN COMPLETELY FORMED IT IS TO BE GIVEN ONE COAT OF WHITE SHELLAC SMOOTHLY APPLIED AND WITHOUT EXCESSIVE RUNS. ALL WIRES SHALL BE SKINNED 1/8" FROM ENDS AND ENDS SHALL BE TWISTED AND TINNED. THE ENDS OF LEADS OF LIKE COLOR BRANCHING FROM A COMMON POINT IN THE CABLE TRUNK SHALL BE TWISTED EXCEPT WHERE NOTED. ALL OTHER LEADS SHALL BE SINGLE.

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 5-C

PRINTER 3-B

These Specifications are the property of the Western Union Telegraph Company and shall not be published.

CONTENTS


| Subject | Paragraph |
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| Closing of Printing Contact and Opening of Sixth Pulse Contact | 11 |
| PRINTING | 12 |
| RESETTING OF SELECTING CARRIAGE FRAME | 15 |
| RESETTING OF SELECTOR BARS | 17 |
| RESTORING PRINTING MECHANISM | 18 |
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| OPERATION OF CARRIAGE RETURN TRAIN | 29 |
| OPERATION OF LINE FEED MECHANISM | 32 |
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| OPERATION OF LETTERS SHIFT MECHANISM | 37 |
| OPERATION OF BELL SIGNAL | 39 |
| ACTION OF RIBBON FEED AND REVERSING MECHANISM | 40 |

SPECIFICATIONS INCLUDED: None.

PHOTOGRAPHS AND DRAWINGS:


| Figure No. | Drawing No. | Title |
|---|---|---|
| 1 | Photograph | Printer 3-B. |
| 2 | 13836- -7 | Printer 3-B Schematic Assembly of Selecting and Printing Mechanism. |
| 3 | 13837- -7 | Printer 3-B Selecting Unit (Left End). |
| 4 | 13838- -7 | Printer 3-B Selecting Unit (Right End). |
| 5 | 13839- -1 | Printer 3-B Selector Bar Pawls and Latches. |
| 6 | 13840- -7 | Printer 3-B Printing Mechanism. |
| 7 | 13841- -7 | Printer 3-B Carriage Return and Spacing Mechanism. |
| 8 | 13842- -1 | Printer 3-B Universal Bar and Ribbon Shield. |
| 9 | 13843- -2 | Printer 3-B Line Feed Mechanism. |
| 10 | 13844- -7 | Printer 3-B Carriage Shift Mechanism. |
| 11 | 13845- -7 | Printer 3-B Ribbon Feed and Reverse Mechanism. |
| 12 | 13846- -2 | Printer 3-B Bell Mechanism. |
| 13 | 22390- -7 | Printer 3-B Wiring Diagram. |
| 14 | 22391- -7 | Printer 3-B Theoretical Wiring Diagram. |

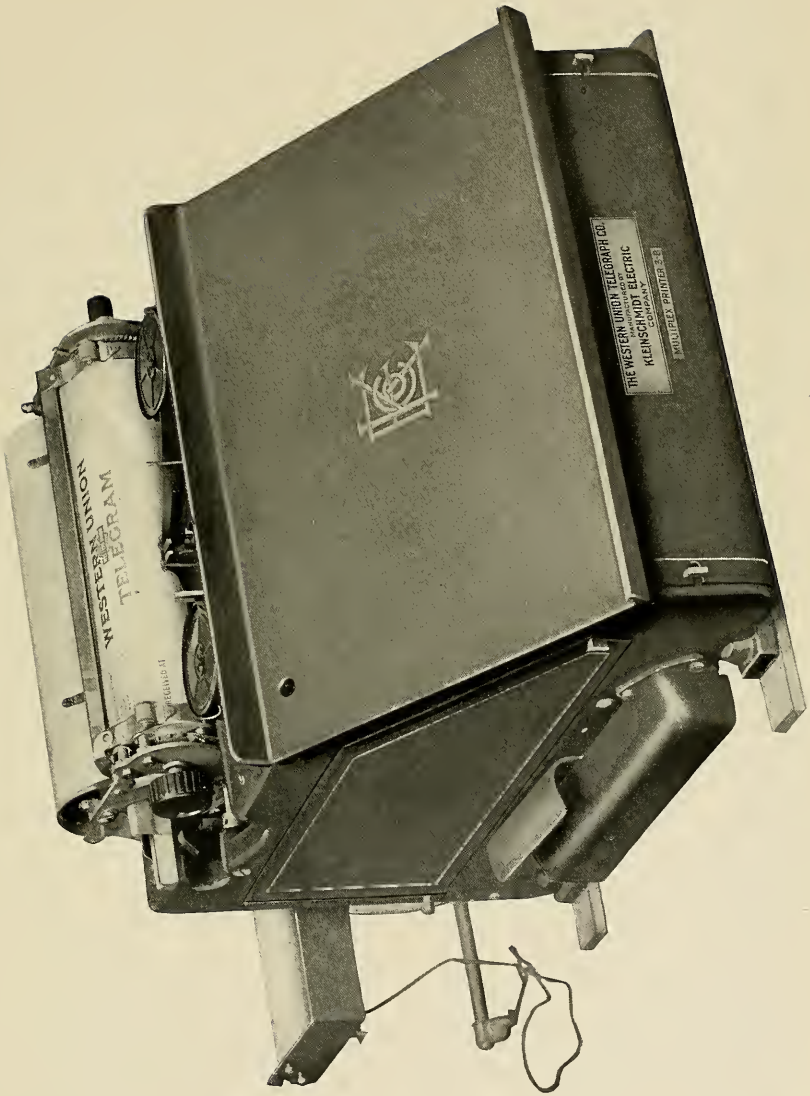

THE WESTERN UNION TELEGRAPH CO.
AND
KLEINSCHMIDT ELECTRIC
COMPANY
MULTIPLEX PRINTER 3-B
WESTERN UNION
TELEGRAM

Fig. 1

## MULTIPLEX PRINTER 3-B

1. In the theoretical description of a possible Multiplex System given in Section 1, the printing of the message was done by an ordinary typewriter to which had been attached a selecting unit and other auxiliary mechanism.

2. In actual service the printing is done by apparatus built specially for this kind of work. This apparatus is known as the printer.

3. This section deals with the 3-B printer, which is one of several types used in connection with the multiplex telegraph system.

4. In the printer under consideration the printing is done by type bars, the proper selection of which is determined by the location of five selector bars which are controlled by five selecting magnets. These magnets are electrically connected to the receiving segments on the distributor.

5. Figure 2 shows a schematic assembly of the selecting and printing units. Figures 3 and 4 show the actual selecting mechanism in normal position. The selecting magnets are numbered from 1 to 5, beginning at the left, and the selector bars which they control are numbered from 1 to 5, starting from the front.

6. Normally all selector bars are in their extreme left hand position and they are properly located when the arms of the selector bar retaining spring bear in the right hand row of notches near the right end of the selector bars (Fig. 2). Each selecting magnet, by means of its armature, controls a selector bar pawl which is mounted on the selecting carriage frame. These pawls rotate about shoulder screws. Selector bar pawls and latches normally have the relative positions as shown at A on Figure 5.

7. When a selecting magnet receives an impulse from its distributor segment, its armature is attracted and the ball point at the rear end of the armature will strike the lower edge of the corresponding selector bar pawl and rotate it counter clockwise against the tension of the adjacent bar pawl spring. As it rotates the right upper edge of the pawl enters a notch in the lower edge of the corresponding selector bar, and when the rotation has gone far enough the selector bar pawl latch, which bears on the edge of the rotating pawl due to the tension of its spring, will drop into the lower notch of the pawl and lock the latter in its upper position. The selector bar pawls and latches will then occupy positions as shown at B on Figure 5.

8. When any selecting magnet armature is operated its rear end strikes a finger attached to the 6th pulse cut-out shaft which carries the 6th pulse cut-out shaft lever (Fig. 4) and rotates the shaft about its pivot screws against the tension of its spring. When the rotation of the shaft has gone far enough to allow the upper end of the cut-out lever to move to the left, the right hand end of this lever will move upward under the action of the 6th pulse contact spring. This motion closes the 6th pulse contact.

9. The closing of the 6th pulse contact completes a circuit (Figs. 13 and 14) by which current may flow from the 6th pulse segment on the distributor through the winding of the 6th pulse relay. Thus a local circuit is closed through the 6th pulse relay armature to the 6th pulse magnet. When a character has been received; that is, after the proper selecting magnets have been energized and the corresponding selector bar pawls locked in their upper positions and the circuit to the 6th pulse magnet completed, this magnet, Figure 3, receives its impulse and attracts its armature, thus shifting the selecting carriage push rod and moving the selecting carriage frame to the right.

10. As the selecting carriage frame starts to move (Fig. 4), its right end strikes the selector bar return lever adjusting screw and causes the selector bar return lever to rotate clockwise about its shaft and to move away from the selector bar return latch lever, before any raised pawl engages with its selector bar. Continued motion of the selecting carriage frame to the right causes all raised pawls to engage the notches in their respective selector bars and to shift the latter to the right also. When these chosen selector bars have been moved far enough for the retaining spring to settle into the left hand row of notches, five slots will have been lined up under the proper pull bar. During the time

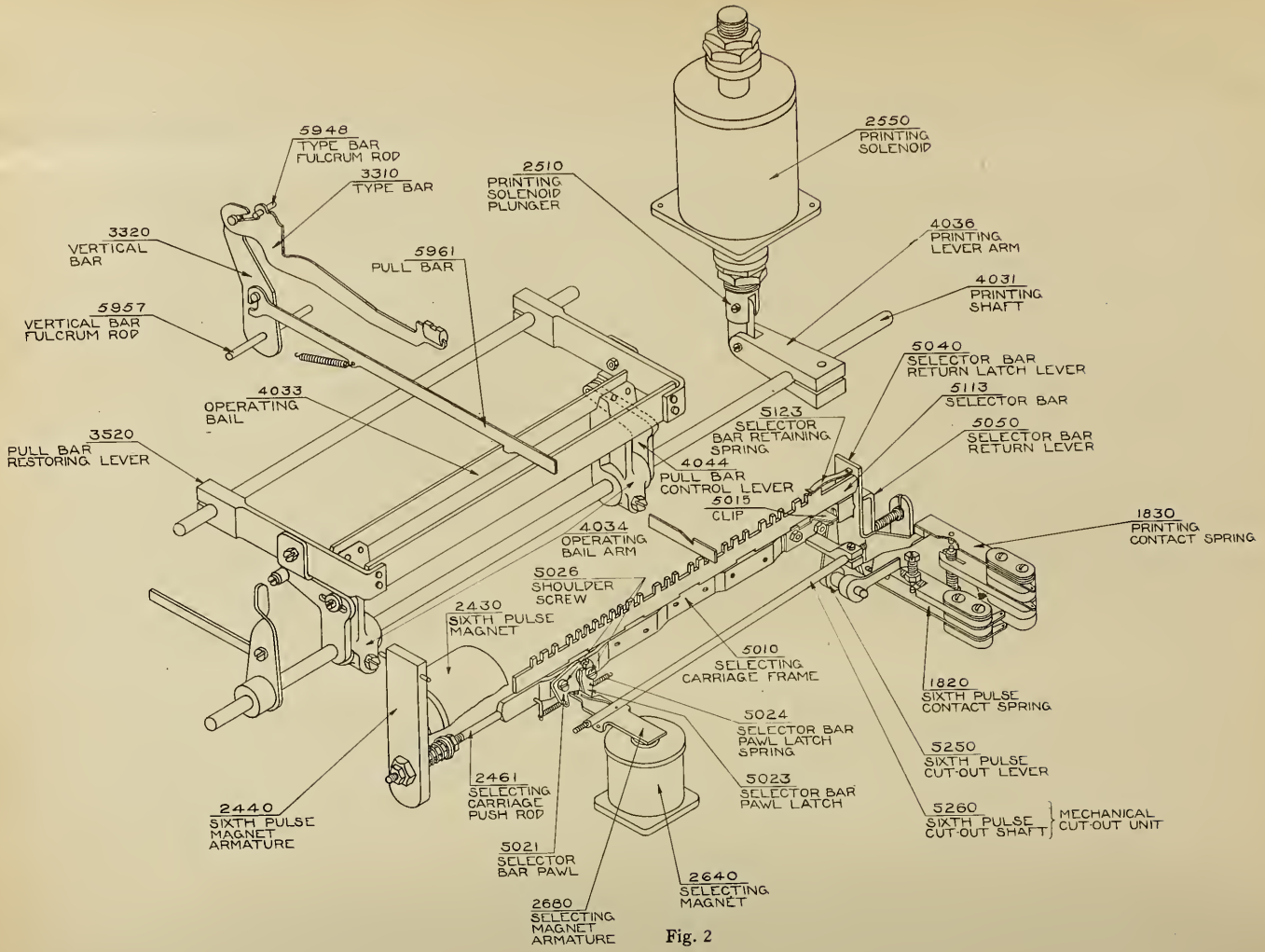
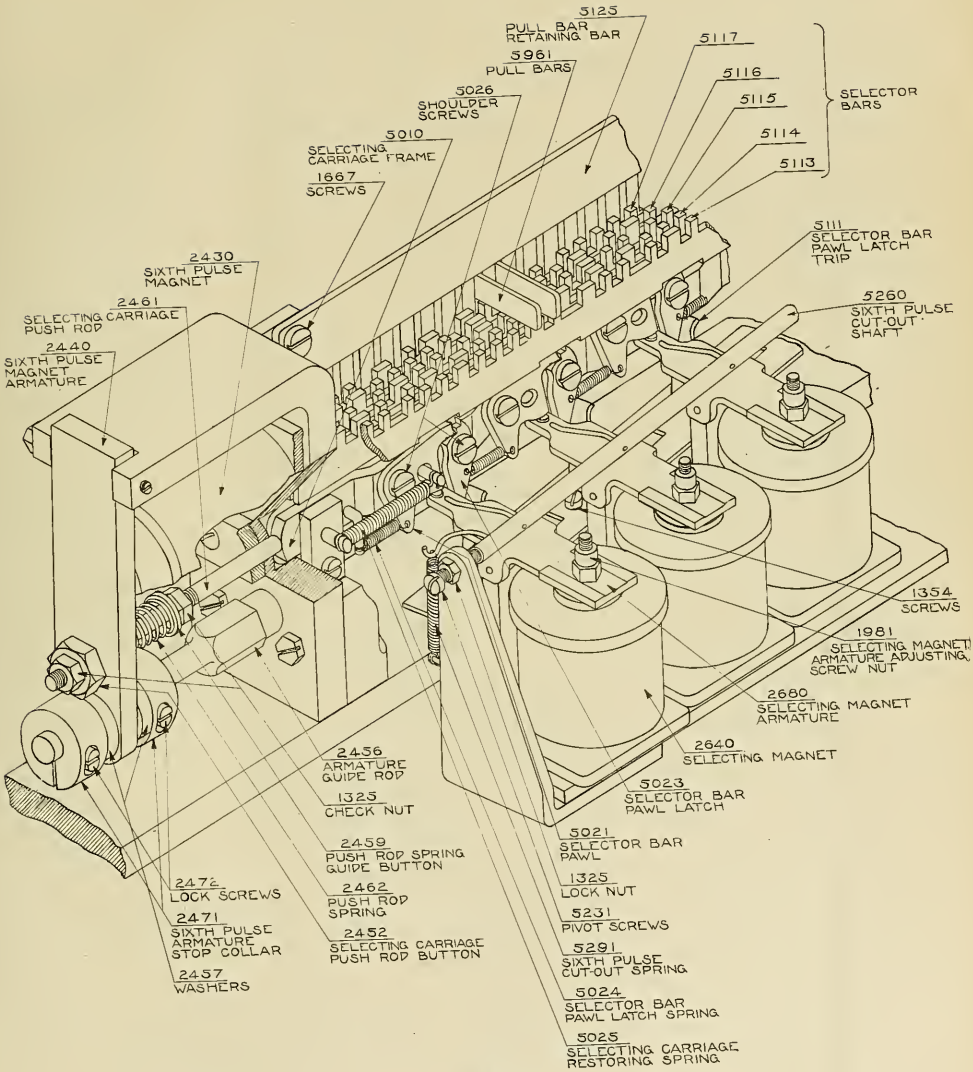

5948
TYPE BAR FULCRUM ROD
3310
TYPE BAR
3320
VERTICAL BAR
5961
PULL BAR
5957
VERTICAL BAR FULCRUM ROD
4033
OPERATING BAIL
3520
PULL BAR RESTORING LEVER
2510
PRINTING SOLENOID PLUNGER
2550
PRINTING SOLENOID
4036
PRINTING LEVER ARM
4031
PRINTING SHAFT
5040
SELECTOR BAR RETURN LATCH LEVER
5113
SELECTOR BAR
5050
SELECTOR BAR RETURN LEVER
5123
SELECTOR BAR RETAINING SPRING
4044
PULL BAR CONTROL LEVER
5015
CLIP
4034
OPERATING BAIL ARM
5026
SHOULDER SCREW
2430
SIXTH PULSE MAGNET
1830
PRINTING CONTACT SPRING
5010
SELECTING CARRIAGE FRAME
1820
SIXTH PULSE CONTACT SPRING
5024
SELECTOR BAR PAWL LATCH SPRING
5250
SIXTH PULSE CUT-OUT LEVER
5023
SELECTOR BAR PAWL LATCH
5260
SIXTH PULSE CUT-OUT SHAFT
MECHANICAL CUT-OUT UNIT
2461
SELECTING CARRIAGE PUSH ROD
2440
SIXTH PULSE MAGNET ARMATURE
5021
SELECTOR BAR PAWL
2640
SELECTING MAGNET
2660
SELECTING MAGNET ARMATURE

Fig. 2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PULL BARS
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SELECTING CARRIAGE FRAME
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SCREWS
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5115
5114
5113
SELECTOR BARS
5111
SELECTOR BAR PAWL LATCH TRIP
2430
SIXTH PULSE MAGNET
2461
SELECTING CARRIAGE PUSH ROD
2440
SIXTH PULSE MAGNET ARMATURE
5260
SIXTH PULSE CUT-OUT SHAFT
1354
SCREWS
1981
SELECTING MAGNET ARMATURE ADJUSTING SCREW NUT
2680
SELECTING MAGNET ARMATURE
2640
SELECTING MAGNET
5023
SELECTOR BAR PAWL LATCH
2436
ARMATURE GUIDE ROD
1325
CHECK NUT
2459
PUSH ROD SPRING GUIDE BUTTON
2462
PUSH ROD SPRING
2452
SELECTING CARRIAGE PUSH ROD BUTTON
5021
SELECTOR BAR PAWL
1325
LOCK NUT
5231
PIVOT SCREWS
5291
SIXTH PULSE CUT-OUT SPRING
5024
SELECTOR BAR PAWL LATCH SPRING
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SELECTING CARRIAGE RESTORING SPRING
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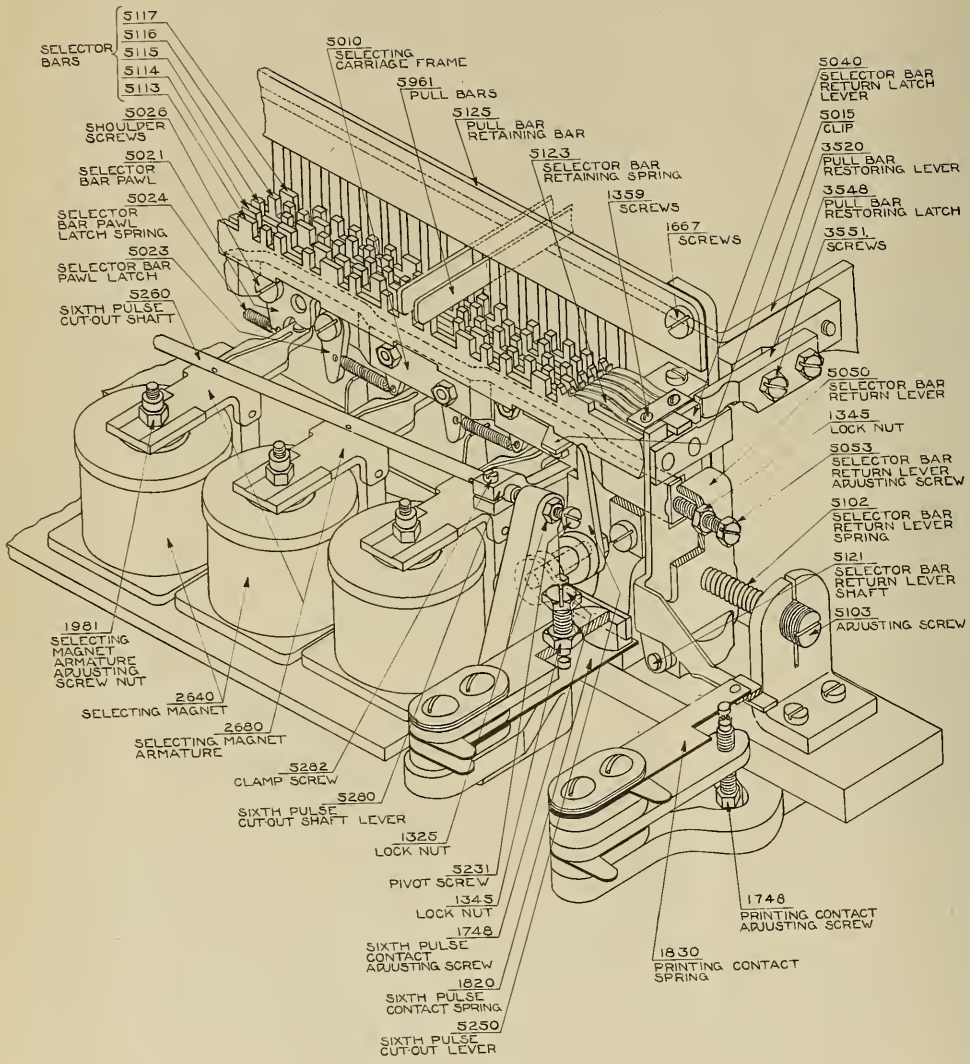
LOCK SCREWS
2471
SIXTH PULSE ARMATURE STOP COLLAR
2457
WASHERS

Fig. 3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SELECTOR BAR RETAINING SPRING
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SCREWS
1667
SCREWS
5040
SELECTOR BAR RETURN LATCH LEVER
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CLIP
3520
PULL BAR RESTORING LEVER
3548
PULL BAR RESTORING LATCH
3551
SCREWS
5026
SHOULDER SCREWS
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SELECTOR BAR PAWL
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SELECTOR BAR PAWL LATCH SPRING
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SELECTOR BAR PAWL LATCH
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SIXTH PULSE CUT-OUT SHAFT
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SELECTOR BAR RETURN LEVER
1345
LOCK NUT
5053
SELECTOR BAR RETURN LEVER ADJUSTING SCREW
5102
SELECTOR BAR RETURN LEVER SPRING
5121
SELECTOR BAR RETURN LEVER SHAFT
5103
ADJUSTING SCREW
1981
SELECTING MAGNET ARMATURE ADJUSTING SCREW NUT
2640
SELECTING MAGNET
2680
SELECTING MAGNET ARMATURE
5282
CLAMP SCREW
5280
SIXTH PULSE CUT-OUT SHAFT LEVER
1325
LOCK NUT
5231
PIVOT SCREW
1345
LOCK NUT
1748
SIXTH PULSE CONTACT ADJUSTING SCREW
1820
SIXTH PULSE CONTACT SPRING
5250
SIXTH PULSE CUT-OUT LEVER
1748
PRINTING CONTACT ADJUSTING SCREW
1830
PRINTING CONTACT SPRING

Fig. 4

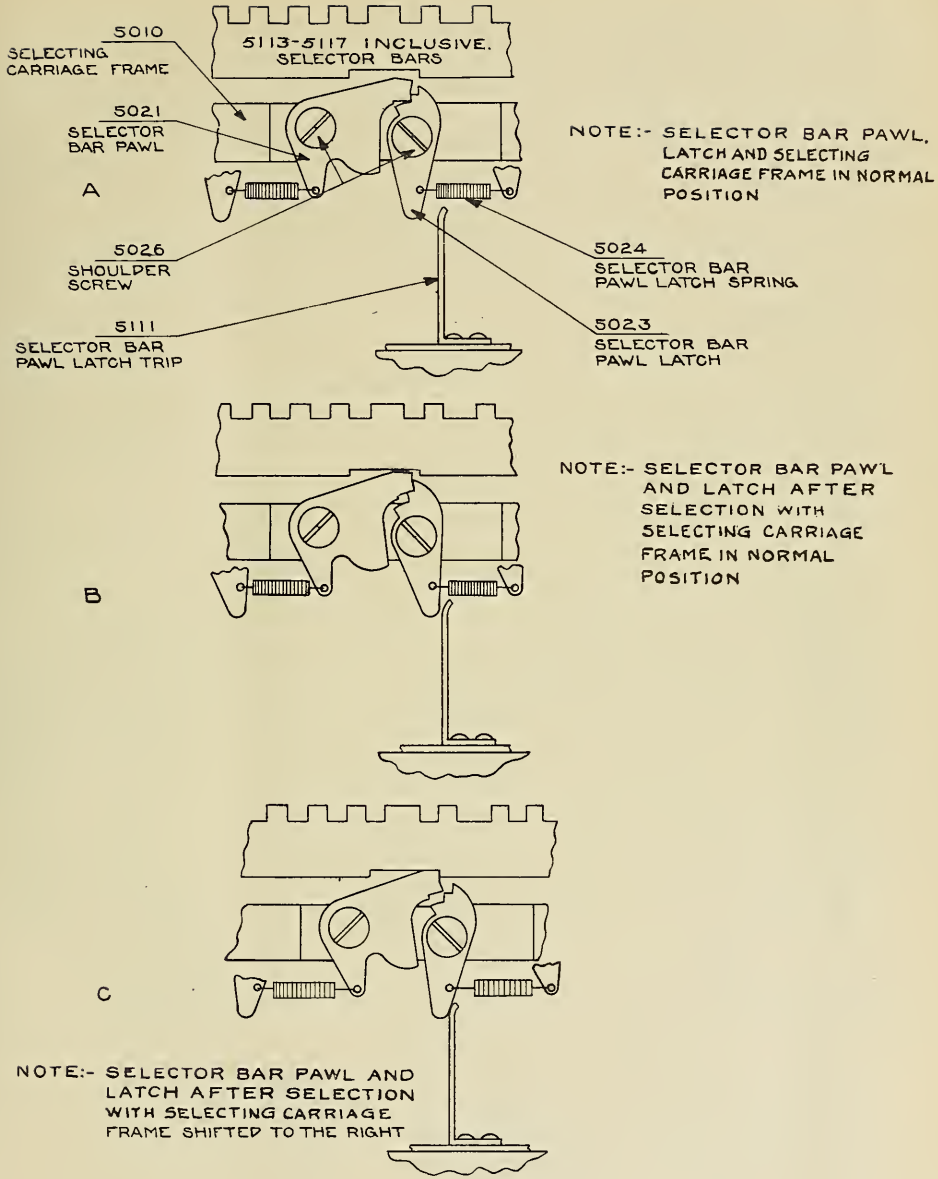

5010
SELECTING CARRIAGE FRAME
5113-5117 INCLUSIVE. SELECTOR BARS
5021
SELECTOR BAR PAWL
A
NOTE:- SELECTOR BAR PAWL, LATCH AND SELECTING CARRIAGE FRAME IN NORMAL POSITION
5026
SHOULDER SCREW
5024
SELECTOR BAR PAWL LATCH SPRING
5111
SELECTOR BAR PAWL LATCH TRIP
5023
SELECTOR BAR PAWL LATCH
B
NOTE:- SELECTOR BAR PAWL AND LATCH AFTER SELECTION WITH SELECTING CARRIAGE FRAME IN NORMAL POSITION
C
NOTE:- SELECTOR BAR PAWL AND LATCH AFTER SELECTION WITH SELECTING CARRIAGE FRAME SHIFTED TO THE RIGHT

Fig. 5

the selector bars are being shifted, their right ends bear against the selector bar return latch lever and cause it to rotate about its shaft in a clockwise direction. The latch on the pull bar restoring lever is tripped just as the selector bars complete their motions, allowing the pull bar restoring lever to drop. When this happens the support for the pull bars will be removed and they will drop downward under the action of their springs. All the pull bars, except the one which is directly above the row of slots in the selector bars, will come to rest on top of the selector bars. The one which is above the slot, however, continues to fall until it rests in the bottom of the prepared slot in the selector bars.

11. As the selecting carriage frame approaches the limit of its motion to the right the horizontal extension of the selector bar return latch lever will have moved downward far enough to permit the printing contacts to close. At practically the same moment the clip on the selecting carriage frame will have engaged the vertical portion of the 6th pulse cut-out lever and rotated it in a clockwise direction. These two operations set in motion two sets of mechanism which perform their functions simultaneously. One of these prints the selected letter; the other prepares the way for resetting the selecting mechanism.

12. When the printing solenoid (Fig. 6) is energized by reason of the closing of the printing contact it raises its plunger and through the printing lever arm rotates the printing shaft and the operating bail arms, thus moving the operating bail in an arc toward the front of the machine. As this bail advances, its upper edge engages a notch on the lower edge of the selected pull bar and draws it forward. The motion of the pull bar is transferred through a vertical bar to the type bar thus causing it to rotate about the type bar fulcrum rod. This rotation moves the type up against the ribbon, paper, and platen, thus causing the selected character to be printed.

13. As the type bar moves up, the rounded part of the bar shown at X on Figure 7 strikes the rim of the universal bar and pushes it back. This closes a contact which energizes the spacing magnet. The subsequent operation of this magnet spaces the carriage immediately after the letter is printed.

14. While the printing is taking place the 6th pulse contact (Fig. 4) is opened by the horizontal arm of the 6th pulse cut-out lever as this lever is rotated by the clip on the selecting carriage frame. The opening of these contacts breaks the 6th pulse relay circuit and de-energizes the 6th pulse magnet (Figs. 13 and 14). The rotation of the 6th pulse cut-out lever also allows the 6th pulse shaft lever to drop off the recess in the vertical arm of the cut-out lever and the cut-out shaft therefore returns to its normal position with the fingers again resting on the rear of the selecting magnet armatures.

15. When the 6th pulse relay circuit is opened the selector bar pawls which carried the selector bars to the right occupy positions as shown at C on Figure 5. As soon as the 6th pulse magnet armature is released the selector bar pawls drop to the lower step on the selector bar pawl latches and the selecting carriage frame is returned to its normal position by the selecting carriage restoring spring (Fig. 3). Selector bar pawls and latches will then occupy positions as shown at A on Figure 4, and all of the selecting unit will have been restored with the exception of the selector bars, which are still held in the selected position by the selected pull bar. It should be noted here that the selecting carriage having been restored, the next selection may now be received, even though the printing and spacing functions are not yet completed.

16. Now, keeping in mind that the restoration of a part of the selecting mechanism takes place simultaneously with the printing of the letter, let us go back to a consideration of the motion of the operating bail immediately after it has given the pull bar sufficient movement to print the selected character.

17. The continued forward motion of the operating bail (Fig. 6) causes the pull bar control levers to raise the pull bar restoring lever, and consequently all pull bars, including the selected bar. As the restoring lever rises, it withdraws the pull bar restoring latch from the catch on the selector bar return latch lever. When this is done the selector bar return latch lever rotates in a counter-clockwise direction under the action of its spring and in so doing returns the selector bars to their normal position, where they will be held by the selector bar retaining springs, and also opens the printing contacts.

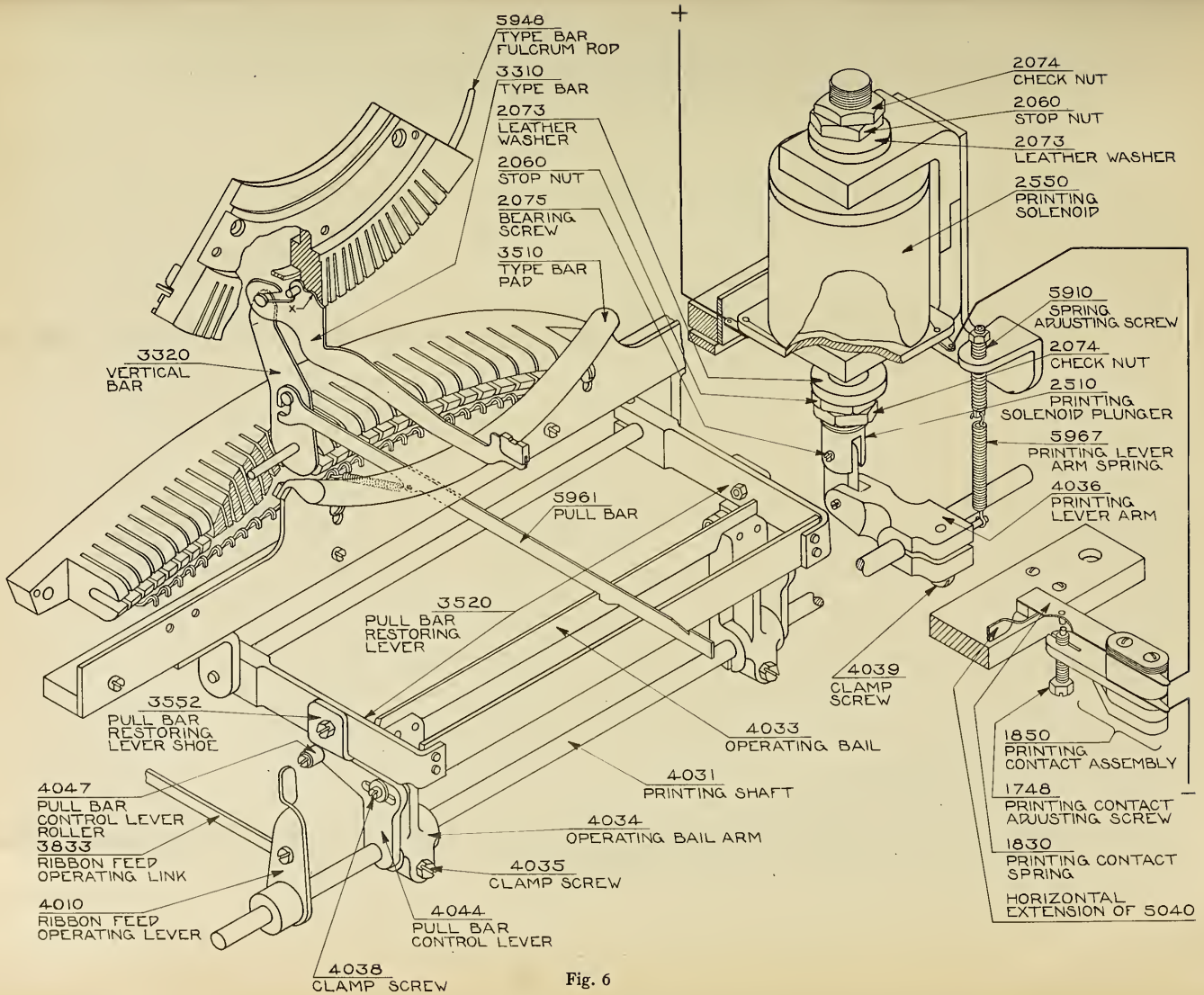

5948
TYPE BAR
FULCRUM ROD
3310
TYPE BAR
2073
LEATHER
WASHER
2060
STOP NUT
2075
BEARING
SCREW
3510
TYPE BAR
PAD
3320
VERTICAL
BAR
5961
PULL BAR
3520
PULL BAR
RESTORING
LEVER
3552
PULL BAR
RESTORING
LEVER SHOE
4047
PULL BAR
CONTROL LEVER
ROLLER
3833
RIBBON FEED
OPERATING LINK
4010
RIBBON FEED
OPERATING LEVER
4038
CLAMP SCREW
4044
PULL BAR
CONTROL LEVER
4035
CLAMP SCREW
4034
OPERATING BAIL ARM
4031
PRINTING SHAFT
4033
OPERATING BAIL
4039
CLAMP
SCREW
2074
CHECK NUT
2060
STOP NUT
2073
LEATHER WASHER
2550
PRINTING
SOLENOID
5910
SPRING
ADJUSTING SCREW
2074
CHECK NUT
2510
PRINTING
SOLENOID PLUNGER
5967
PRINTING LEVER
ARM SPRING
4036
PRINTING
LEVER ARM
1850
PRINTING
CONTACT ASSEMBLY
1748
PRINTING CONTACT
ADJUSTING SCREW
1830
PRINTING CONTACT
SPRING
HORIZONTAL
EXTENSION OF 5040

Fig. 6

18. The opening of the printing contacts de-energizes the printing solenoid, the printing plunger therefore falls and, aided by the printing lever arm spring, restores the printing train to its normal position. When this operation is completed the entire printing mechanism is restored to its normal position.

19. As previously mentioned the rounded part of the selected type bar strikes the rim of the universal bar during the upward stroke. This serves to close the spacing contact, which in turn energizes the spacing solenoid and causes the printer carriage to advance one letter space to the left, placing it in position to receive the impression of the next character. From this description it will be seen that the operation of spacing the printer carriage between letters is automatically accomplished and that it does not require a separate selection and operation of the printer between letters.

20. The operation of spacing the carriage will now be described in more detail. Referring to Figure 7 it will be seen that the universal bar is supported on two arms, one of which mounts a contact roller. Normally the roller rests on the spacing contact spring and holds open the spacing contact. However, when the universal bar moves to the rear this roller moves away from the contact spring and the spacing contact is closed. The spacing solenoid is then energized, and the plunger is drawn into the solenoid (Fig. 8), extending the spacing spring and allowing the point of the spacing pawl to drop with the next tooth on the spacing ratchet. A retaining pawl prevents the spacing ratchet from unwinding during this operation.

21. When the selected type bar drops away from the universal bar, after the letter has been printed, the universal bar spring (Fig. 7) forces the contact roller against the spacing contact spring and opens the spacing contact. This de-energizes the spacing solenoid and the spacing pawl spring (Fig. 8) forces the point of the spacing pawl into the new tooth on the spacing ratchet, rotating the spacing shaft and advancing the printer carriage one letter space.

22. The description of the printer operation just completed is necessarily long. It might be well, therefore, to review the operation of the printer in performing a given function. Assume that the letter to be selected and printed is the letter "E." The different parts of the printer will then operate in accordance with the following table of operating sequence:

23.

1. No. 1 selecting magnet operated.
2. 6th pulse cut-out mechanism tripped.
3. 6th pulse cut-out contact closed.
4. No. 1 selecting bar pawl locked up.
5. 6th pulse relay operated.
6. 6th pulse relay locked up.
7. 6th pulse magnet operated.
8. Selecting carriage frame moved to right.
9. Selecting bar return lever rotated.
10. No. 1 selector bar moved to right and selecting bar return latch lever rotated.
11. A. Latch on pull bar restoring lever tripped, permitting the E pull bar to fall into selected slot.
    B. 6th pulse contacts opened and cut-out mechanism reset. This starts the resetting of the selecting mechanism, which then operates independently in the following sequence:
    1. Selecting carriage frame moves to left.
    2. No. 1 selecting bar pawl reset.
    C. Printing contacts close. This starts the operation of the printing train, which then operates independently in the following sequence:
    1. Printing solenoid operates.
    2. Operating bail moves forward.
    3. Type bar thrown up.
    4. a. Letter "E"

| | | |
|---|---|---|
| (The remaining steps in the resetting of the selecting mechanism follow certain of the printing train functions as shown under 11-C.) | printed.<br>5. Pull bar restoring lever raised.<br>6. Printing contacts opened.<br>7. Latch on pull bar restoring lever reset.<br>8. No. 1 selector bar reset. | b. Spacing contacts closed. This starts the operation of the spacing train which then operates independently in the following sequence:<br>1. Spacing solenoid operated.<br>2. Spacing pawl spring extended.<br>3. Spacing contact opened.<br>4. Carriage spaced. |

**24.** The operation of printing any letter is similar to the operation described for the letter "E," the only difference being in the selection of the selecting bars required for the different letters.

**25.** If we wish to perform some function other than printing, such as returning the carriage after a line of printing has been completed, the operation of the printer is somewhat different for each function. The operation of each function, as well as the function units, will therefore be described individually.

**26.** When it is desired to space the carriage without printing, as between words, No. 3 selecting magnet is operated. This causes the spacing type bar to be selected. This type bar is similar in its action in all respects to the one described above except that it is not fitted with type and consequently when it is thrown up no character is printed (Fig. 7).

**27.** In order to prevent the spacing mechanism from operating after the printer carriage has reached the end of a line of printing a spacing cut-out contact has been provided. The location of this contact and its action is shown in Figure 8. The spacing cut-out contact which is really a protective device is connected in series with the spacing contact and is shunted with a 200 ohm resistance unit. The purpose of this resistance will be explained later. A bracket located underneath the carriage strikes a fibre block on the end of spacing cut-out contact spring when the carriage has reached the limit of its travel and opens this contact. Further operation of the spacing contact does not operate the spacing solenoid and consequently the carriage is not jammed against its stop.

**28.** When the printer has finished a line of printing it is necessary that the carriage be returned so that the succeeding line of printing shall start with the same margin from the left edge of the paper as the line just completed. This function is performed by the carriage return mechanism.

**29.** The operation of the carriage return train follows the operation of No. 4 selecting magnet. Following the selection of the carriage return pull bar and the operation of the printing solenoid, the support for the carriage return contact spring (Fig. 8) will be removed and the contacts will be closed. An electrical circuit will then be established (Figs. 13 and 14) so that the carriage return magnet will be energized and attract its armature, thereby closing the carriage return locking contact a-b. Thus a locking circuit is formed, holding the magnet operated until the carriage returns and the bracket underneath the carriage strikes the carriage return break contact spring and opens contact c-d.

**30.** The operation of returning the carriage is a mechanical process and follows directly after the attraction of the carriage return armature (Fig. 8). The carriage is supported at three points on ball bearings. At the rear of the upper ball race is a rack, cut with a rounded face so as to work equally well in the lower case or upper case position. Engaging this rack is the spacing gear fixed to the end of the spacing shaft. This

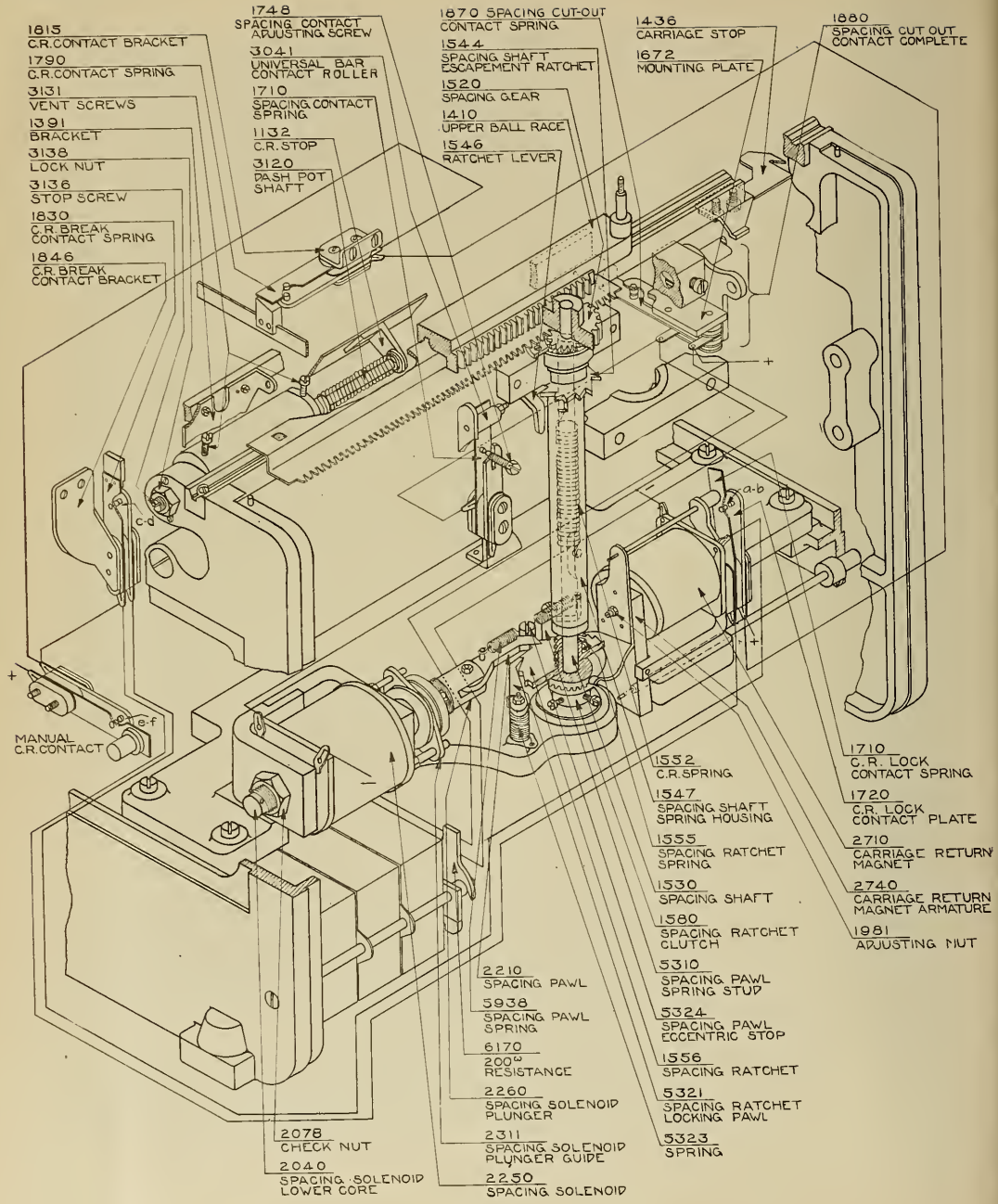

1815
C.R. CONTACT BRACKET
1790
C.R. CONTACT SPRING
3131
VENT SCREWS
1391
BRACKET
3138
LOCK NUT
3136
STOP SCREW
1830
C.R. BREAK CONTACT SPRING
1846
C.R. BREAK CONTACT BRACKET
1748
SPACING CONTACT ADJUSTING SCREW
3041
UNIVERSAL BAR CONTACT ROLLER
1710
SPACING CONTACT SPRING
1132
C.R. STOP
3120
PUSH POT SHAFT
1870 SPACING CUT-OUT CONTACT SPRING
1544
SPACING SHAFT ESCAPEMENT RATCHET
1520
SPACING GEAR
1410
UPPER BALL RACE
1546
RATCHET LEVER
1436
CARRIAGE STOP
1672
MOUNTING PLATE
1880
SPACING CUT OUT CONTACT COMPLETE
MANUAL C.R. CONTACT
1552
C.R. SPRING
1547
SPACING SHAFT SPRING HOUSING
1555
SPACING RATCHET SPRING
1530
SPACING SHAFT
1580
SPACING RATCHET CLUTCH
1710
C.R. LOCK CONTACT SPRING
1720
C.R. LOCK CONTACT PLATE
2710
CARRIAGE RETURN MAGNET
2740
CARRIAGE RETURN MAGNET ARMATURE
1981
ADJUSTING NUT
2210
SPACING PAWL
5938
SPACING PAWL SPRING
6170
200Ω RESISTANCE
2260
SPACING SOLENOID PLUNGER
2311
SPACING SOLENOID PLUNGER GUIDE
2250
SPACING SOLENOID
5310
SPACING PAWL SPRING STUD
5324
SPACING PAWL ECCENTRIC STOP
1556
SPACING RATCHET
5321
SPACING RATCHET LOCKING PAWL
5323
SPRING
2078
CHECK NUT
2040
SPACING SOLENOID LOWER CORE

Fig. 7

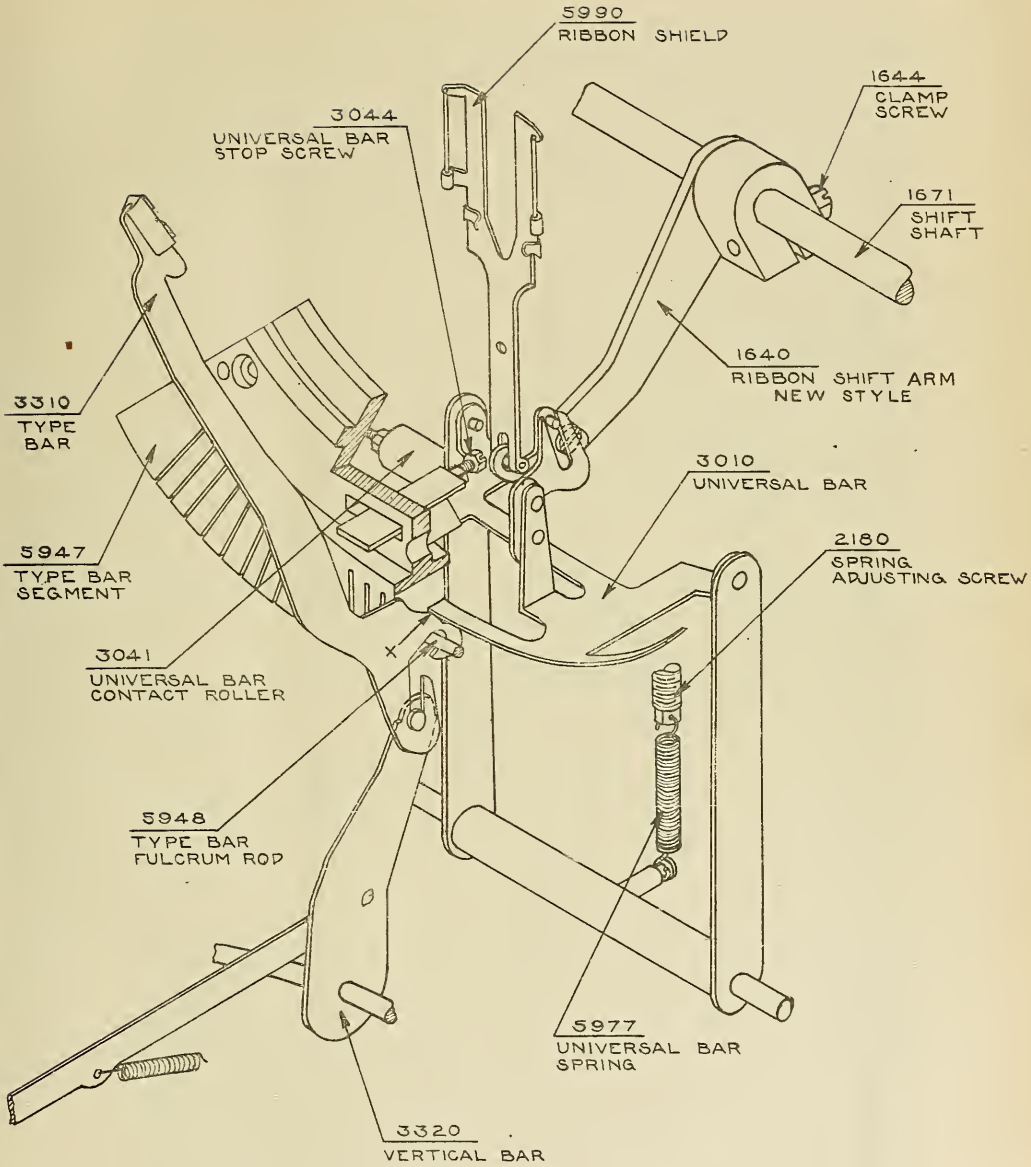

5990
RIBBON SHIELD
1644
CLAMP SCREW
3044
UNIVERSAL BAR STOP SCREW
1671
SHIFT SHAFT
1640
RIBBON SHIFT ARM NEW STYLE
3310
TYPE BAR
3010
UNIVERSAL BAR
2180
SPRING ADJUSTING SCREW
5947
TYPE BAR SEGMENT
3041
UNIVERSAL BAR CONTACT ROLLER
5948
TYPE BAR FULCRUM ROD
5977
UNIVERSAL BAR SPRING
3320
VERTICAL BAR

Fig. 8

shaft turns in bearings at its upper and lower ends. Wound on the outside of this shaft is the carriage return spring, one end of which is attached to the shaft, the other end being held in a slot at the upper end of the shaft housing. This housing is free to turn on the spacing shaft, except as it is restrained by the escapement ratchet lever. The spacing ratchet clutch is attached to the lower end of the spacing shaft just above its lower bearing. The upper surface of this clutch is toothed. The spacing ratchet is mounted loosely on the spacing shaft between the lower end of the housing and the clutch. The spacing ratchet spring tends to force the ratchet downward so that the teeth on its lower surface engage those on the upper surface of the clutch. This is the normal position for the spacing ratchet and when so located forms a solid connection for the transmission of the motion of the spacing pawl from the pawl point to the carriage by means of the spacing ratchet, the spacing ratchet clutch, the spacing shaft, and spacing gear. However, when the carriage return magnet attracts its armature, the horizontal extension of the armature bears on the lower side of the spacing ratchet and lifts the latter so that its teeth clear those on the clutch and removes from the carriage return spring the restraining action of the spacing and locking pawls. The carriage return spring therefore unwinds and rotates the spacing shaft, thus moving the carriage to its Zero position ready for a new line printing. Before the carriage gets all the way back, the carriage return stop strikes the end of the dash pot shaft and drives the latter into its cylinder until the rear end hits the stop screw. Due to the retarding action of the vent screws, free flow of air through the ports at either end of the buffer cylinder is prevented. Thus an air cushion is formed ahead of the piston and a vacuum is formed behind it, thereby minimizing the shock of the return. Inasmuch as a locking circuit is provided it is necessary for the main carriage return contacts to be closed only long enough to close the contact a-b. The latter circuit, as before stated, is broken at contact c-d by the bracket underneath the carriage, just before the carriage reached its Zero position.

31. For convenience in returning the carriage by hand, two manual carriage return buttons are provided. One of these, located at the rear of the printer on the left hand side, operates the carriage return armature mechanically, the other one, located near the front of the printer on the right hand side, operates the carriage return electrically (Figs. 13 and 14).

32. When it becomes necessary to start a new line of printing, the carriage platen which carries the paper must be rotated one or more line spaces. This rotation is performed by the line feed mechanism.

33. The operation of the line feed train is initiated by the operation of No. 2 selecting magnet. Following the selection of the line feed pull bar and the operation of the printing solenoid, the support for the line feed contact spring (Fig. 9) will be removed and the line feed contact will be closed thereby completing an electrical circuit (Figs. 13 and 14) to the line feed solenoid. Referring again to Figure 9, when the latter is energized its plunger is drawn downward. The ball bearing roller which is mounted on the L shaped head of the plunger engages the line feed bail and gives it a downward rotation about the line feed bail shaft bearings. As the bail moves downward, the vertical arm at the end of the bail moves to the rear and draws the line feed pawl with it. Normally the line feed pawl bears on the front eccentric stop and in this position the pawl point is held clear of the teeth of the line feed ratchet. During the motion described above the feed pawl pivots on its shoulder screw. The line feed pawl spring tends to keep the line feed pawl in engagement with the rim of the line feed ratchet. Consequently after the pawl has been drawn a fraction of its motion to the rear, the pawl point will fall until it engages a tooth of the ratchet. During the next period of the motion of the line feed pawl it will rotate the ratchet against the tension of the jockey roller arm spring until the jockey roller has moved over the high point of the succeeding tooth. Finally the pawl will come to rest against the rear eccentric stop. When the line feed contacts are reopened and the line feed solenoid is de-energized, the line feed plunger is forced upward by the line feed bail spring, one end of which is attached to the carriage frame and the other end of which is attached to the line feed bail, rotates the latter upward to its normal position. The vertical arm at the end of the bail necessarily moves

forward and pushes the line feed pawl with it. The inclined front edge of the line feed pawl rides up on the front stop until the vertical arm comes to rest again in its normal position. As the line feed pawl moves forward the pawl point moves over the back of the next tooth to be engaged by it and comes to rest slightly in front of and above it.

**34.** The type slugs at the end of the type bars carry two characters. Those nearest to the type bar fulcrum rod are letters of the alphabet. The remaining, or upper case, characters comprise the numerals, punctuation marks, etc. In order to print them it is necessary to first raise or shift the printer carriage in order to bring the printing line on the platen opposite to the required upper case character. The mechanism used in shifting and unshifting the carriage will now be discussed.

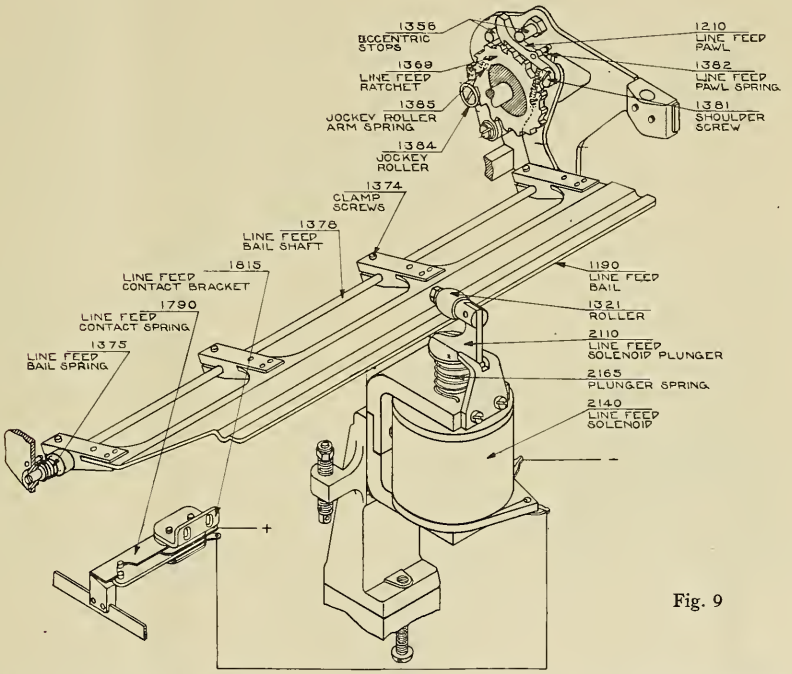



Fig. 9

**35.** The operation of shifting the carriage is initiated by the operating of selecting magnets 1, 2, 4 and 5. Following this the shift pull bar (Fig. 10) is dropped into the prepared slot in the selector bars. This action removes the support for the shift contact spring and allows the shift contact to close, thus completing an electrical circuit to the shift solenoid (Figs. 13 and 14). During the first part of the travel of the shift solenoid plunger the shift latch lever is rotated about its shoulder screw against the tension of the shift latch lever spring until the curved foot on its horizontal extension bears on the shift shaft. When this occurs the hook at the upper end of the lever will clear the shift stop. Continued motion of the shift solenoid plunger rotates the shift shaft and all its attachments about its bearings, which are fixed in the printer side frames. The carriage is supported at the rear on two ball bearings, carried in a retainer, which run in shaped grooves on the upper and lower ball races. This retainer maintains the two balls at all times at the maximum allowable spacing. At the front the carriage

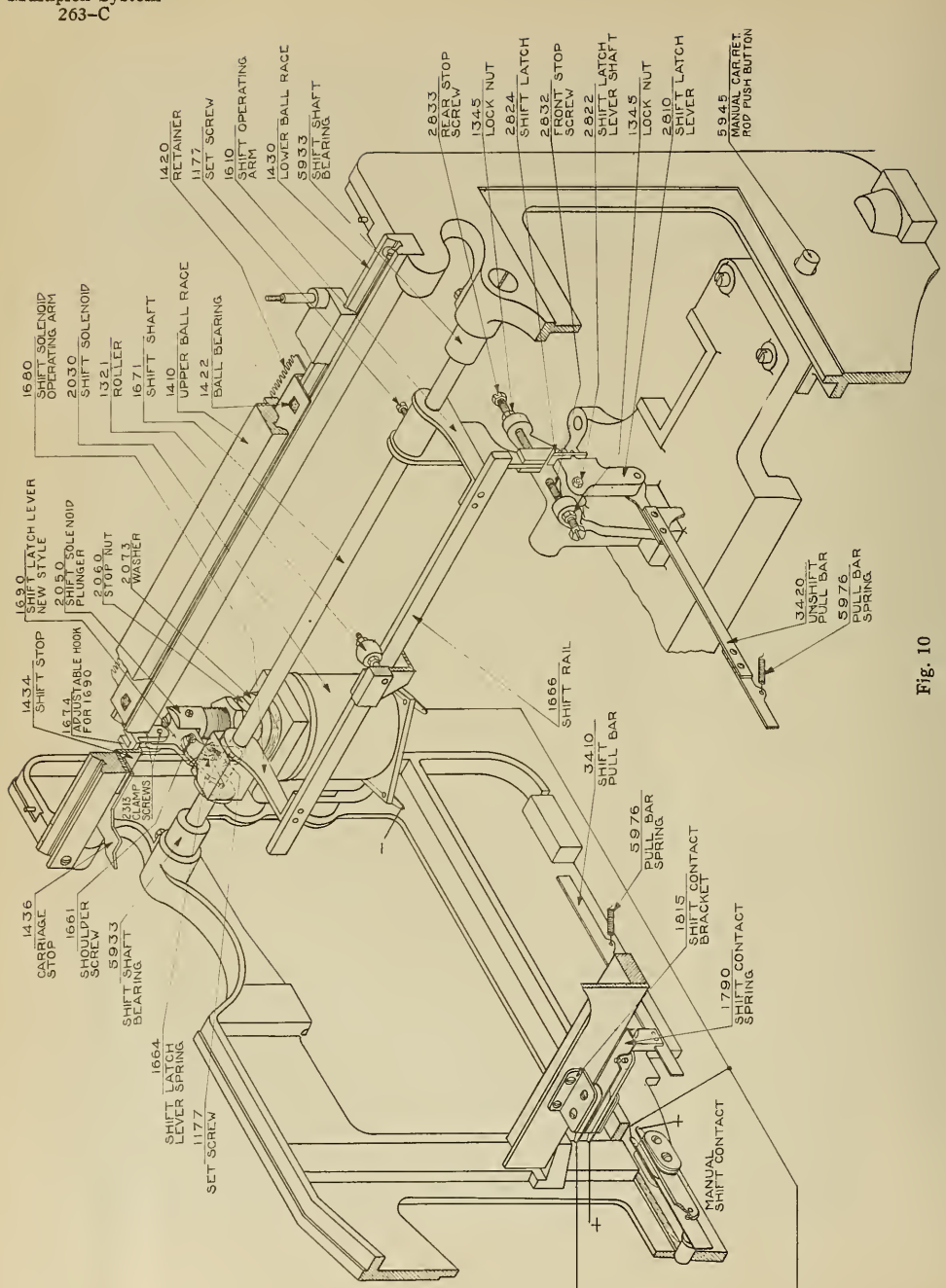

1420 RETAINER
1177 SET SCREW
1610 SHIFT OPERATING ARM
1430 LOWER BALL RACE
5933 SHIFT SHAFT BEARING
2833 REAR STOP SCREW
1345 LOCK NUT
2824 SHIFT LATCH
2832 FRONT STOP SCREW
2822 SHIFT LATCH LEVER SHAFT
1345 LOCK NUT
2810 SHIFT LATCH LEVER
5945 MANUAL CAR RET. ROD PUSH BUTTON
1680 SHIFT SOLENOID OPERATING ARM
2030 SHIFT SOLENOID
1321 ROLLER
1671 SHIFT SHAFT
1410 UPPER BALL RACE
1422 BALL BEARING
1690 SHIFT LATCH LEVER NEW STYLE
2050 SHIFT SOLENOID PLUNGER
2060 STOP NUT
2073 WASHER
1434 SHIFT STOP
1674 ADJUSTABLE HOOK FOR 1690
2315 CLAMP SCREWS
1436 CARRIAGE STOP
1661 SHOULDER SCREW
5933 SHIFT SHAFT BEARING
1664 SHIFT LATCH LEVER SPRING
1177 SET SCREW
1666 SHIFT RAIL
3410 SHIFT PULL BAR
5976 PULL BAR SPRING
1815 SHIFT CONTACT BRACKET
1790 SHIFT CONTACT SPRING
MANUAL SHIFT CONTACT
3420 UNSHIFT PULL BAR
5976 PULL BAR SPRING

Fig. 10

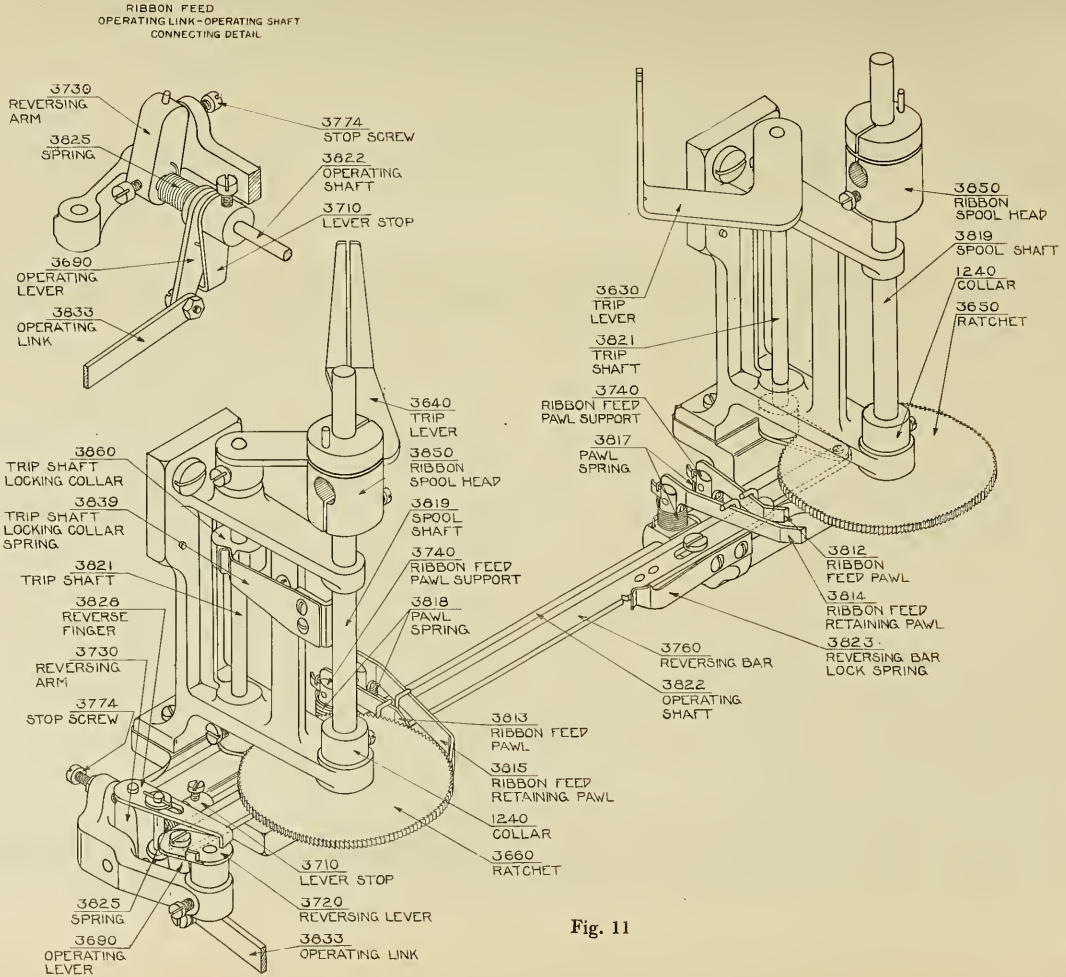

RIBBON FEED
OPERATING LINK-OPERATING SHAFT
CONNECTING DETAIL
3730
REVERSING
ARM
3825
SPRING
3774
STOP SCREW
3822
OPERATING
SHAFT
3710
LEVER STOP
3690
OPERATING
LEVER
3833
OPERATING
LINK
3640
TRIP
LEVER
3650
RIBBON
SPOOL HEAD
3819
SPOOL
SHAFT
3740
RIBBON FEED
PAWL SUPPORT
3818
PAWL
SPRING
3860
TRIP SHAFT
LOCKING COLLAR
3839
TRIP SHAFT
LOCKING COLLAR
SPRING
3821
TRIP SHAFT
3826
REVERSE
FINGER
3730
REVERSING
ARM
3774
STOP SCREW
3813
RIBBON FEED
PAWL
3815
RIBBON FEED
RETAINING PAWL
1240
COLLAR
3660
RATCHET
3710
LEVER STOP
3720
REVERSING LEVER
3825
SPRING
3690
OPERATING
LEVER
3633
OPERATING LINK
3850
RIBBON
SPOOL HEAD
3819
SPOOL SHAFT
1240
COLLAR
3650
RATCHET
3630
TRIP
LEVER
3821
TRIP
SHAFT
3740
RIBBON FEED
PAWL SUPPORT
3817
PAWL
SPRING
3812
RIBBON
FEED PAWL
3814
RIBBON FEED
RETAINING PAWL
3823
REVERSING BAR
LOCK SPRING
3760
REVERSING BAR
3822
OPERATING
SHAFT

Fig. 11

rests on the shift roller which runs on the shift rail. Normally the vertical leg of the shift operating arm rests against the rear stop screw. The location of this screw determines the normal (lower case) position of the carriage. As the shift plunger is drawn into its solenoid and the shift rail is raised, the carriage is rotated upward about the two ball bearings at the rear. During the operation of the shifting the shift operating arm rotates forward and the beveled end of its vertical leg ratchets over the shift latch and strikes the front stop screw just after the shift plunger bottoms on its leather washer. Under the action of the unshift pull bar the shift latch snaps back to its normal position in time to engage the vertical leg of the shift operating arm as the latter rebounds slightly. Thus the carriage is locked in the shifted or upper case position.

36. Since it is sometimes convenient to shift the carriage by hand, a manual shift contact is located on the left side of the printer at the front of the machine. As shown on Figures 13 and 14 it is wired in parallel with the automatic shift contact.

37. The unshift operation is purely mechanical. The operation of unshifting the carriage is initiated by the operation of selecting magnets 1, 2, 3, 4 and 5. Following this the 6th pulse magnet operates and the unshift pull bar (Fig. 10) is dropped into the prepared slot in the selector bars. As the operating bail engages this pull bar and draws it forward the shift latch lever is rotated about its shaft far enough to release the vertical leg of the shift operating arms and the carriage drops of its own weight until it comes to rest with the vertical leg of the shift operating arm bearing on the rear shift lever stop screw. The hook of the shift latch lever will at the same time engage the shift stop thereby preventing the carriage from being moved to its upper case position until the shift solenoid is again energized.

38. To make it possible to unshift the carriage by hand a manual unshift button is located on the right hand side of the printer near the rear. When this button is depressed a bell crank is rotated against the extension of the unshift pull bar. This causes the shift latch lever to rotate about its shaft, thus releasing the shift operating arm and unshifting the carriage.

39. In order to provide a means for signalling the printer operator without mutilating the message which is being received at the time, a signal bell is used. The operation of the bell signal requires first the shifting of the carriage to upper case and then the selection and operation of the J pull bar (Fig. 10). When the carriage is shifted the shift operating arm which carries the bell contact takes up a position such that the beveled fibre block on the end of the flat bell contact spring is directly beneath and about 1/32 inch away from the hooked end of the bell contact lever. The rotation of the shift latch lever about its shaft by the action of the J pull bar causes the hook to slide over the beveled block at the end of the contact spring and to open the bell contacts. Referring to Figures 13 and 14 it will be noted that the bell contact just opened forms part of a circuit which shunts the bell solenoid winding. Normally this contact is closed and forms a low resistance path for current to pass to the spacing solenoid. When this path is broken, however, sufficient current will flow through the bell solenoid to operate it but the current flowing through the spacing solenoid will be insufficient to operate the latter. The bell solenoid plunger will be thrown against the gong, thus ringing the bell. Since it is possible that the printer carriage might be at the extreme end of a line of printing and thus hold open the spacing cut-out contact when the bell signal is received, a shunting resistance of 200 ohms is placed around this contact to provide a path for the current to the spacing solenoid. In this way there is no danger of losing the bell signal whatever may be the position of the printer carriage.

40. A standard one-half inch typewriter ribbon is used on 3B printers. An automatic ribbon feeding and reversing mechanism is provided. The source of power for the operation of the ribbon feed and reverse mechanism is the printing solenoid. The ribbon feed lever (Fig. 6) attached to the printing shaft transfers the motion to the ribbon feed operating link (Fig. 14). The rear end of this link is attached to the lower end of the operating lever. This lever is constructed with a long sleeve and is free to turn (within certain limits) on the ribbon feed operating shaft. The ribbon feed reversing arm is fixed to this shaft and is joined to the operating lever by a spring. Hence a flexible

connection is provided between the printing shaft and the ribbon feed operating shaft. In addition to the parts already mentioned, the operating shaft mounts a lever stop and a right and left ribbon feed pawl support. The ribbon feed lever stop regulates the tension of the driving connecting spring. The feed pawl supports are mounted, one on the left of the center bearing of the operating shaft, and the other on the right of the right hand bearing and close enough to these bearings to prevent end play in the shaft. Over each of the bearings just mentioned is mounted a retaining pawl support. All pawls are constantly under tension of their respective springs and one set, depending on the position of the ribbon feed reversing bar, is engaged with the teeth of the corresponding ribbon feed ratchet. By the train of mechanism described above the operation of the printing solenoid causes the active pawl to be drawn to the rear into engagement with a new tooth on its ratchet. The retaining pawl meanwhile remains in a tooth of the ratchet and prevents counter rotation. When the printing solenoid is de-energized and its plunger falls to its normal position, the feed pawl, now in a new tooth of the ratchet, moves forward, thereby rotating the ratchet a fixed amount. The returning pawl will follow over an equal amount and come to rest in a new ratchet tooth. The rotation of the ratchet also causes the vertical ribbon feed spool shaft to which it is attached to rotate. At the top of each shaft is fixed a ribbon spool head and keyed loosely to the latter is a ribbon spool. Consequently, as either shaft turns the ribbon will be wound on its spool. During the time that one set of pawls is operative, the opposite set is held away from the ratchet and the ribbon is free to unwind from the spool mounted on that side.

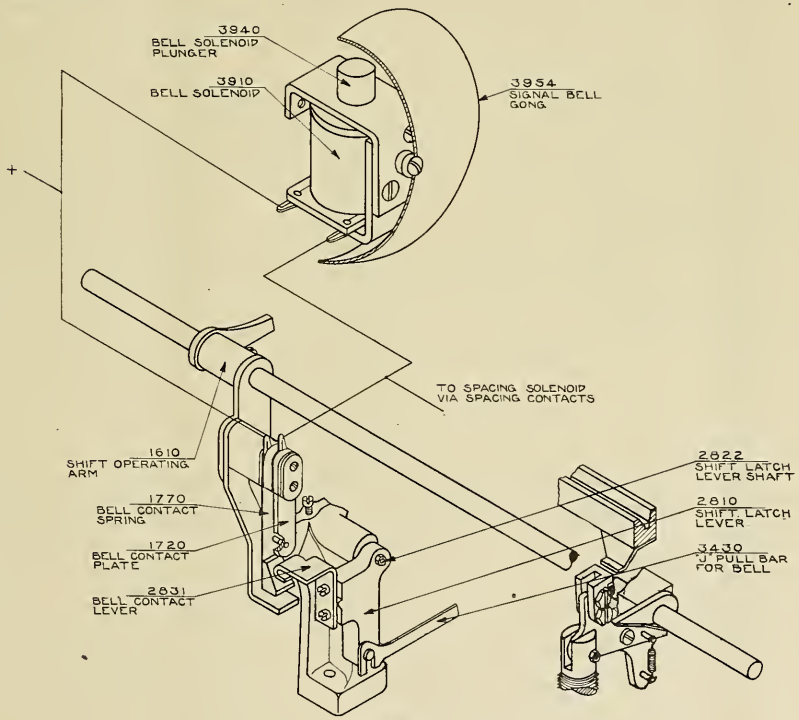



Fig. 12

41. A short distance from each end of the ribbons which are used on 3-B printers is located a reversing eyelet. When the ribbon has been unwound far enough from either spool the reversing eyelet at that end of the ribbon will come in contact with the sides of the slot in the adjacent ribbon feed trip lever. As the ribbon continues to unwind from this spool the adjacent trip lever will be drawn over, thus rotating its shaft so that the detent point of the trip shaft locking collar moves past the detent spring. This motion causes the ribbon feed reverse finger to move about its pivot to its opposite extreme position. On the next stroke of the printing solenoid the finger will be drawn to the rear, drawing the lug on the ribbon feed reversing lever with it and thus rotating this lever to its opposite position. This rotation will throw the ribbon feed reversing bar past its lock spring to its opposite position and in so doing the pins on the reverse bar will bear on and throw the original set of pawls out of contact with their ratchet. The opposite set of pawls will be released from the pins on the reversing bar and will bear on the rim of their ratchet. Hence the direction of feed will be reversed and succeeding strokes of the operating mechanism will feed the ribbon onto the empty spool.

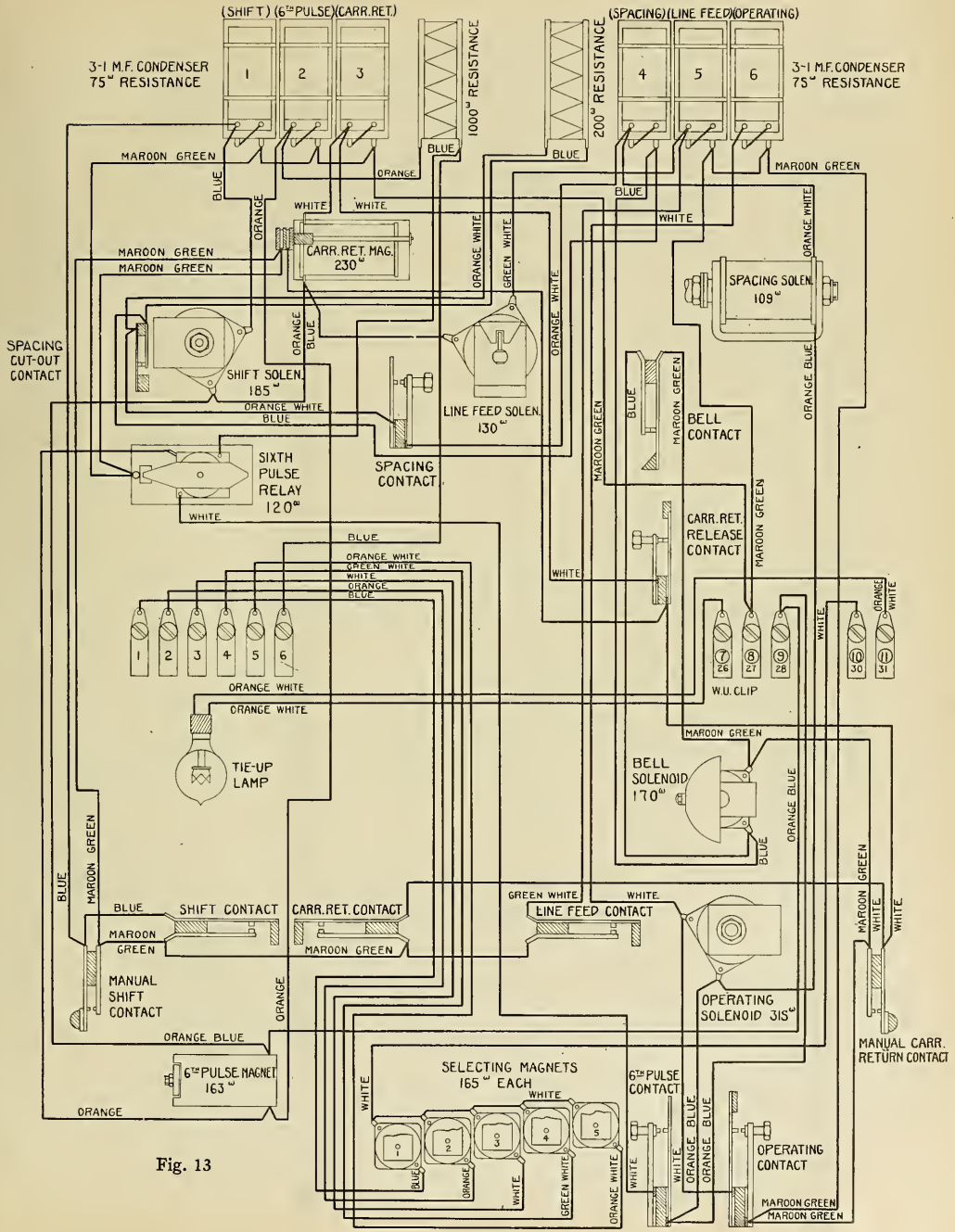
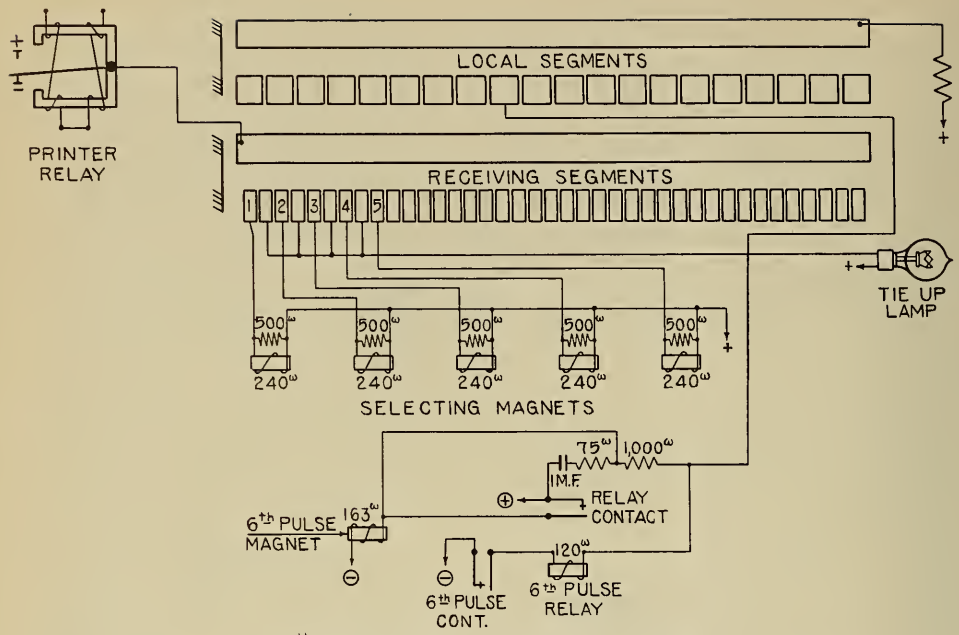
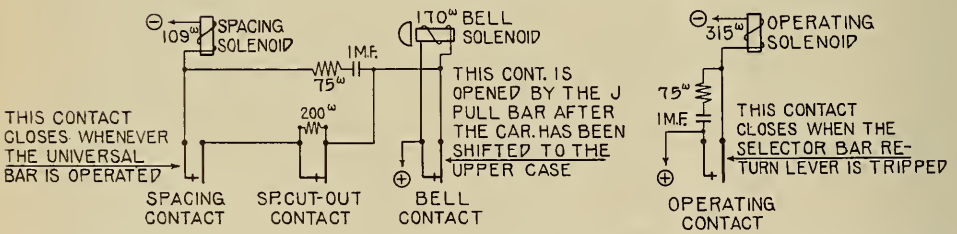
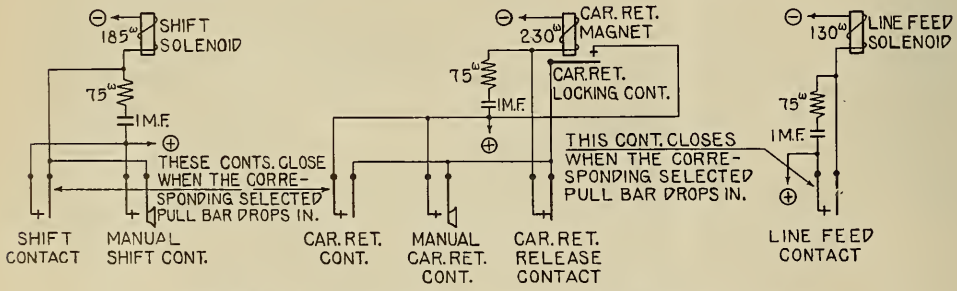

(SHIFT) (6TH PULSE) (CARR. RET.)
(SPACING) (LINE FEED) (OPERATING)
3-1 M.F. CONDENSER 75Ω RESISTANCE
1000Ω RESISTANCE
200Ω RESISTANCE
3-1 M.F. CONDENSER 75Ω RESISTANCE
MAROON GREEN
BLUE
ORANGE
WHITE
CARR. RET. MAG. 230Ω
SPACING SOLEN. 109Ω
SPACING CUT-OUT CONTACT
SHIFT SOLEN. 185Ω
LINE FEED SOLEN. 130Ω
SIXTH PULSE RELAY 120Ω
SPACING CONTACT
BELL CONTACT
CARR. RET. RELEASE CONTACT
ORANGE WHITE
GREEN WHITE
W.U. CLIP
TIE-UP LAMP
BELL SOLENOID 170Ω
SHIFT CONTACT
CARR. RET. CONTACT
LINE FEED CONTACT
MANUAL SHIFT CONTACT
OPERATING SOLENOID 315Ω
MANUAL CARR. RETURN CONTACT
6TH PULSE MAGNET 163Ω
SELECTING MAGNETS 165Ω EACH
6TH PULSE CONTACT
OPERATING CONTACT

Fig. 13




6th PULSE CONTACT CLOSED BY MECHANICAL CUT-OUT WHEN SELECTION IS MADE.


109ω SPACING SOLENOID
I.M.F.
75ω
200ω
THIS CONTACT CLOSES WHENEVER THE UNIVERSAL BAR IS OPERATED
SPACING CONTACT
SP. CUT-OUT CONTACT
170ω BELL SOLENOID
THIS CONT. IS OPENED BY THE J PULL BAR AFTER THE CAR. HAS BEEN SHIFTED TO THE UPPER CASE
BELL CONTACT
315ω OPERATING SOLENOID
75ω
I.M.F.
THIS CONTACT CLOSES WHEN THE SELECTOR BAR RETURN LEVER IS TRIPPED
OPERATING CONTACT




THE BATTERY POLARITIES MARKED ⊕ OR ⊖ REMAIN CONSTANT AS SHOWN FOR ALL CHANNELS. ALL OTHER POTENTIALS ARE CORRECT ONLY FOR A AND C CHANNELS. FOR B AND D CHANNELS THESE POTENTIALS ARE REVERSED.

Fig. 14

## ADJUSTMENTS

1. **General.** In the following paragraphs instructions are given for the adjustments which are necessary in order to put 3-B printers in the best operating condition. In addition to these specific directions it may be well to note here that all parts of the printer shall be kept clean and free from dust and dirt. Printer covers shall be in place at all times, except when work is being done on the machine which necessitates their removal. Moving parts, with the exception of solenoid plungers and type bars, shall be oiled from time to time so as to keep the machines working freely. The latch on the selector bar return latch lever (Fig. 4) shall be oiled once a day.

2. **Selector Bar Retaining Spring.** With all selector bars to the right, locate the selector bar retaining spring (Fig. 4) so that the ends of all five arms of the spring bear evenly in the left hand row of notches near the right ends of the corresponding selector bars.

3. **Selector Bar Return Lever Spring.** The selector bar return lever spring (Fig. 4) opposes the operation of the 6th pulse magnet and therefore in order to maintain maximum operating speed in the magnet the compression of this spring must be kept as light as possible. With the printer in normal condition, loosen the lock nut and back off the selector bar return lever adjusting screw so that it is clear of the selecting carriage frame. Then move all five selector bars to the right until the latch on the pull bar restoring lever drops. Now lift the latch and at the same time hold back on the return latch lever. Allow the return latch lever to return to the left slowly under the action of its spring. Adjust this spring by means of its screw so as to give a compression just sufficient to reset all five selector bars in this way. When this point is reached advance the adjusting screw one-half turn more.

4. **Selector Bar Pawl Latch Trip.** With the selector bars in normal position loosen the mounting for the selector bar pawl latch trip screws and trip No. 1 selector bar pawl (Fig. 3). Operate the 6th pulse magnet armature slowly by hand and set the selector bar pawl latch trip as far to the left as possible, still allowing the selector bar pawl to engage with the right vertical face of the notch on the under side of its selector bar before it is released by the corresponding selector bar pawl latch. It is essential that this adjustment be correct to prevent loss of impulses. The selector bar pawl latches must be tripped as soon as the pawls are in proper engagement with their selector bars. After making the adjustment just described, trip all five selecting magnet armatures and operate the 6th pulse magnet armature so that all five selector bars are thrown to the right and the latch on the pull bar restoring lever has dropped (Fig. 4). Release the 6th pulse magnet armature, retrip all five selecting magnet armatures and operate the 6th pulse magnet armature slowly while watching the selector bar pawl latches. All should be tripped at the same time. The vertical legs on the selector bar pawl latch trip may be bent slightly (using wrench No. 6152) to bring this about. If this adjustment is not made correctly the selector bar pawls may not have time to drop to their normal positions after each operation and impulses will be gained as a result.

5. **6th Pulse Magnet.** Trip all five selector bar pawls (Figs. 3 and 4). Loosen the lock screws and move the sixth pulse armature stop collars (Fig. 3) to the right and left, along the armature guide rod, so that they do not interfere with the motion of the armature. Loosen push rod check nuts and spread them apart on the selecting carriage push rod. Then loosen the push rod buttons so as to reduce the compression in the push rod spring. Set the right stop collar on the armature guide rod so that when the armature is pressed firmly against the washer there will be a clearance of .005 inch between the armature and the core of the 6th pulse magnet. With the 6th pulse armature in this position, press the push rod to the right so that all the selector bars are held in their extreme right positions. Then locate the selecting carriage push rod button so that a clearance of from .004 inch to .008 inch exists between it and the side of the armature. Lock this button in place with its check nut.

6. **Left Stop for 6th Pulse Armature.** Fasten the left 6th pulse armature guide collar by means of its lock screw to the armature guide rod (Fig. 3) so that when successive pawls are tripped the distance between the right edges of the selector bar pawl

latches and the sides of the corresponding vertical legs of the selector bar pawl latch trip will be as small as possible consistent with the proper engagement of each pawl with its selector bar, when the 6th pulse magnet is operated. The selecting carriage push rod button shall be held against the 6th pulse magnet armature while the above adjustment is being made.

7. **Selecting Carriage Return Lever Adjusting Screw.** With the 6th pulse magnet armature resting against its left stop and with the selecting carriage push rod button (Fig. 3) held tightly against the armature, advance the selector bar return lever adjusting screw (Fig. 4) so that it just touches the end of the selecting carriage frame and then give it one-quarter turn more. Lock the screw in this position with check nut.

8. **Push Rod Spring Guide Button.** Adjust the push rod spring guide button (Fig. 3) so that the compression of the push rod spring will be sufficient to allow the 6th pulse magnet armature to push all five selector bars to the right without allowing a gap between the selecting carriage push rod button and the side of the armature while the latter is moving from its left to its right stop. Lock the spring guide button in place with its check nut.

9. **Selecting Magnet Armatures.** When a selecting magnet armature (Figs. 3 and 4) has rotated its selector bar pawl just far enough to lock the pawl in its upper position, the armature should come to rest against the core of its selecting magnet. Check each of the five selecting armatures and see that this condition obtains. Armatures may be bent slightly by using wrench No. 6152.

10. **Selecting Magnet Armature Stop Nuts.** Locate the selecting magnet armature adjusting screw nuts (Figs. 3 and 4) so that when the selecting armatures are in their normal (unoperated) position a play of from .004 inch to .008 inch exists between the ball points at the rear of the armatures and the lower edges of these respective selector bar pawls.

11. **6th Pulse Relay.** Adjust the 6th pulse relay contact screw so that with the contact points closed the armature just clears the magnet. Adjust the armature spring so that a force of from 60-80 grams applied at the contact end of the relay armature is required to close the contact points. The normal gap between these points should be from .010 inch to .015 inch.

12. **Cut-out Mechanism.** Loosen the 6th pulse cut-out shaft lever on the 6th pulse cut-out shaft and slide it to the left out of the way (Fig. 4). Adjust the cone point pivot screws supporting the cut-out shaft so that the ends of the fingers on the shaft bear on the centers of the selecting magnet armatures. The pivot screws shall be so set with respect to each other that the end play in the shaft is as small as possible and so that when the spring attached to the left end of the shaft (Fig. 3) is removed the fingers will drop of their own weight when raised and released. Lock the pivot screws with their lock nuts. Apply local current to the printer. Operate the 6th pulse magnet by intermittently holding down the relay armature. Lower the 6th pulse contact adjusting screw (Fig. 4) until the 6th pulse relay holds operated. Then back off the screw until both the 6th pulse relay and magnet are de-energized. This will be a definite point, inasmuch as the clip on the selecting carriage frame holds the 6th pulse cut-out lever in a definite position as long as the 6th pulse magnet is energized. Raise the contact screw one-quarter turn more and lock with its check nut. Remove the local current from the printer. The 6th pulse contact spring shall have sufficient tension so that a force of from 40 to 50 grams applied at the end of the spring will be required to open the contact points from a closed position. Trip any selector bar pawl, thereby raising the rear end of the corresponding finger on the cut-out shaft. Now slide the 6th pulse cut-out shaft lever to the right along the contact shaft and tighten the clamp screw so that the lever is just latched up on the notch in the vertical leg of the 6th pulse contact lever. Repeat this operation with each selector pawl. Clear the printer after each check before proceeding with the next one. If any case is found in which the 6th pulse cut-out shaft lever does not drop into the notch of the 6th pulse cut-out lever, the shaft

lever must be reset as described before, using this armature as a guide. After this adjustment has been made, operate the 6th pulse magnet slowly and see that the clip on the selecting carriage frame moves the arm of the cut-out lever far enough to the right to disengage the lever. If this condition does not obtain, the shaft lever must be moved farther to the left on the cut-out shaft and the above set of adjustments must be rechecked.

13. **Pull Bar Restoring Lever Latch.** Trip No. 1 selector bar pawl and operate the 6th pulse magnet armature slowly by hand. Adjust the pull bar restoring lever latch (Fig. 4) by means of its mounting screws so that it will be tripped just as this selector bar reaches its extreme right hand position. Check this adjustment for each selector bar. At the same time the latch shall be located vertically so that when in the normal position a clearance of .010 inch exists between the bottom of the pull bars and the tops of the selector bars. Characters may be dropped out if this adjustment is not carefully made.

14. **Type Bar Pad.** The purpose of the type bar pad (Fig. 6) is to form a rest for the type bars. It shall be located at such a level that when the type bars are resting on it, and the upper end of the slots in the rear of the type bars are seated on the type bar fulcrum rod, the bearing rivets at the upper ends of vertical bars will have a slight forward and backward play in the lower ends of the slots in the type bar.

15. **Removal of Type Bars.** Referring to Figure 7 it will be seen that when the universal bar is pushed back out of the way the type bar may be lifted from its fulcrum rod. When the type bar is clear of the fulcrum rod it may be pushed to the rear until the rivet at the top of the vertical bar is opposite the opening in the type bar. The type bar may then be easily removed and is accessible for cleaning, etc. Care must be taken not to bend or deform the type bar in any way, as the alignment of the printing will be affected thereby.

16. **Operating Bail and Left Pull Bar Control Lever.** Loosen all attachments to the printing shaft (Fig. 6). Loosen the clamp screws holding the right and left hand pull bar control levers and lower them. Fasten the operating bail arms to the printing shaft with their clamp screws so that the operating bail extends under all the pull bar restoring lever shoes. In making this adjustment care must be taken not to twist the operating bail; i. e., the bail must be kept parallel to the line of notches in the pull bars. Tighten the clamp screw on the left hand pull bar control lever so that the functioning pull bars are tripped when the type is from one-half to three-fourths inches from the platen.

17. **Right Pull Bar Control Lever.** Set the right hand pull bar control lever (Fig. 5) so that its roller bottoms on the right pull bar restoring lever shoe at the same time as the one on the left.

18. **Printing Solenoid Plunger Stop Nut (Upper).** Adjust the upper printing solenoid plunger stop nut so that about 1 3/16 inches of the printing solenoid plunger (measured from the bottom of the printing solenoid frame to the center of the link bearing screw) projects beneath the solenoid frame. Rotate the printing shaft so as to bring the working edge of the operating bail from 1/16 inch to 1/8 inch behind the notches in the pull bars. With the printing shaft in this position, tighten the clamp screw in the printing lever arm.

19. **Printing Solenoid Plunger Stop Nut (Lower).** Adjust the lower printing solenoid plunger stop nut (Fig. 6) so that the leather washer comes to a bearing on the solenoid frame just after the pull bar control levers have lifted the pull bar restoring lever and the latter has been latched up by the catch on the selector bar return latch lever (Fig. 4). Lock both upper and lower plunger stop nuts with their check nuts.

20. **Printing Lever Arm Spring.** Printing lever arm spring (Fig. 6) increases the speed of the return of the operating train. If the tension is too great it will produce light printing. The tension shall never be reduced sufficiently to cause the printing to be heavy enough to show indentations on the back of the printed page.

21. **Printing Contact Adjusting Screw.** Referring to Figure 4, set the printing contact adjusting screw so that this contact is almost closed. Then apply current and move

the top of the selector bar return latch to the right by hand. This will allow the printing contact to close and the printing solenoid to lift the restoring lever. Then allow the selector bar return latch to return slowly to its normal position under the latch, observing the distance that the catch on the return latch lever travels under the restoring latch before the latter drops. Repeat this operation until an adjustment of the contact screw is obtained that will allow the catch to get under the latch approximately 1/16 inch before the contact is broken and the latch drops. The printer contact spring shall be adjusted by bending so that a force of from 120 to 140 grams applied at the end of the spring will be necessary to open the contact points.

22. **Pull Bar Retaining Bar.** Adjust the pull bar retaining bar (Fig. 4) by means of its mounting screw so that a distance of from .005 to .010 inch exists between the tops of the pull bars and the bottom of the retaining bar when the operating bail is held forward.

23. **Universal Bar Stop Screw.** The edge of the universal bar (Fig. 7) which comes in contact with the rounded portion X of the type bars must be parallel to the type bar fulcrum rod in the segment about which the type bars rotate so that the type at the ends of all type bars is an equal distance from the platen when the type bars strike the universal bar. Adjust the universal bar stop screw so that it strikes the back of the type bar segment and holds the universal bar in such a position that when the T type bar is raised its rounded portion X will strike the edge of the universal bar when the type is about one and one-half inches from the platen.

24. **Universal Bar Spring.** Set the adjusting screw in the universal bar spring (Fig 7) so as to make the tension of this spring sufficient to require a force of from 30 to 45 grams applied at the upper end of any type bar to force the type against the platen.

25. **Spring Pawl Eccentric Stop.** Adjust the spacing pawl eccentric stop (Fig. 8) so that when the spacing pawl bears on the top the spacing ratchet locking pawl will just drop into a ratchet tooth. With both pawls in this position there must be no play of the spacing ratchet in either direction.

26. **Spacing Pawl Spring.** Set spacing pawl spring stud (Fig. 8) so that the tension of the spacing pawl spring will be sufficient to space the carriage near the end of a line of printing against a force of 300 grams applied parallel to the platen shaft. The tension of the carriage return spring may be increased by winding up the spacing shaft spring housing and may be reduced by operating the spacing shaft ratchet escapement lever. The escapement ratchet is attached to the carriage return spring housing.

27. **Spacing Solenoid Plunger Travel.** Energize the spacing solenoid and adjust the spacing solenoid plunger so that the spacing pawl will just drop into a new ratchet tooth. Then give the plunger one-half turn more, allowing the spacing plunger to be drawn into its casing an additional amount equal to one-half the pitch of the thread on the plunger. Lock the plunger guide with its clamp screws. This will provide a clearance between the point of the spacing pawl and the edges of the ratchet teeth. Bring the spacing solenoid lower core to bearing on the end of the solenoid plunger, back off one-quarter turn and lock in place with its check nut.

28. **Spacing Contact.** The spacing contact adjusting screw (Fig. 8) shall be set so that the spacing contacts will close when the type on the T type bar is from one and one-quarter to one and one-half inches from the platen. If this adjustment does not give the spacing magnet sufficient time to operate at a speed of 60 words per minute the contact screw may be advanced slightly. The spacing contact spring shall be adjusted so that a force of 75 grams applied at the top of the spring will be required to increase the normal opening of the spacing contact.

29. **Spacing Cut-out Contact.** Adjust the spacing cut-out contact (Fig. 8) by means of the plate mounting screws so that the lower edge of the bracket under the carriage strikes the fibre block at the end of the spacing cut-out contact spring and opens the contact when the carriage is at the end of a line of 72 characters. The normal opening of the spacing cut-out contact is .020 inch and the tension of the contact spring shall be adjusted so that a force of 45 to 60 grams applied at the end of this spring is required to open the contact points.

30. **Carriage Return Contact.** Adjust the carriage return contact bracket (Fig. 8) so that with the pull bar restoring lever tripped and with the pull bars resting on the selector bars the carriage return contact points will be open from .010 inch to .012 inch. The bracket has elongated holes which make it adjustable, thus affording a means of setting the contact opening at the proper amount. The tension of the carriage return contact spring should be adjusted so that a force of 100 to 125 grams applied at the end of the spring will be required to increase this normal opening.

31. **Carriage Stop.** Operate the armature of the carriage return magnet (Fig. 8) by hand, thereby raising the spacing ratchet until the teeth in its lower surface are clear of those on the upper surface of the spacing ratchet clutch. The latter is attached to the spacing shaft and under the action of the carriage return spring and through the spacing gear and the rack on the upper ball race the carriage will be driven to the left, as seen on Figure 7, until the carriage return stop strikes the end of the dash pot shaft and drives the latter against its stop screw. Now release the armature, loosen the lock nut and adjust the dash pot shaft stop screw so that the teeth on the lower surface of the spacing ratchet drop into and accurately fit those on the upper surface of the spacing ratchet clutch. Lock the stop screw in this position with its lock nut.

32. **Dash Pot.** Adjust the dash pot vent screws (Fig. 8) in both ends of the dash pot cylinder so that the carriage will return from the end of a line of printing and settle into its Zero position in the time interval necessary for the reception of two characters; i. e., carriage return and line feed.

33. **Carriage Return Magnet Armature Back Stop.** Adjust the carriage return magnet armature stop (Fig. 8) so that when the carriage return magnet is unoperated a clearance of from .005 inch to .010 inch exists between the top of the horizontal extension of the armature and the lower face of the spacing ratchet. When the carriage return magnet is operated a similar opening should exist between the tops of the teeth of the spacing ratchet and the spacing ratchet clutch.

34. **Locking Circuit Break Contact.** Set the carriage return break contact bracket (Fig. 8) so that the carriage return break contacts will close after the carriage has spaced once. A force of 50 grams applied at the end of the contact spring shall be required to open this contact.

35. **Locking Circuit Controls.** The carriage return locking contact (Fig. 8) must normally be open from .030 inch to .040 inch. A force of 100 grams applied at the end of the contact spring shall be required to close the contacts. The contact plate may be bent to obtain the required opening.

36. **Manual Carriage Return Contacts.** The manual carriage return contact at the front right side of the printer (Fig. 8) shall normally be open about .050 inch. A force of not less than 40 grams on the button projecting from the side frame shall be required to close these contacts.

37. **Line Feed Contacts.** Trip the pull bar restoring lever and adjust the line feed contact bracket (Fig. 9) by its mounting screws so that with the pull bars resting on the selector bars the line feed contacts are open from .010 inch to .012 inch. The tension of the line feed contact spring shall be adjusted so that a force of from 100 to 125 grams applied at the end of the spring will be required to increase this normal opening.

38. **Front Eccentric Stop.** Rotate the platen by hand until the jockey roller (Fig. 9) is seated in a tooth of the line feed ratchet. Then adjust the front eccentric stop so that normally the line feed pawl point is lifted high enough to permit free rotation of the platen in either direction.

39. **Solenoid Plunger Travel and Rear Eccentric Stop.** Operate the line feed solenoid plunger (Fig. 9) by hand until the jockey roller is seated in the next tooth of the line feed ratchet. Hold the line feed plunger operated and raise the lower core (not shown) so that it just bears on the bottom of the line feed solenoid plunger. Also adjust the rear eccentric stop so that it just bears on the rear edge of the line feed pawl.

40. **Line Feed Bail Spring.** The tension of the line feed bail spring (Fig. 9) shall be sufficient to return the line feed bail and its train without failing when the printer is operating at 65 words per minute. This tension may be regulated by loosening the clamp screws in the bail arms and turning the slotted head of the line feed bail shaft with a screwdriver.

41. **Shift Contact.** The shift contact bracket (Fig. 10) shall be set so that with the restoring bar tripped; that is, with the pull bars resting on the tops of the selector bars, the contact opening is from .010 inch to .012 inch. The bracket has elongated holes which make it adjustable, thus affording a means of setting the contact opening at the proper amount. The tension of the shift contact spring shall be adjusted so that a force of from 100 to 125 grams applied at the end of the spring will be required to increase this normal opening.

42. **Shift Rail Frame.** Loosen the set screws (Fig. 10) which attach the two arms to the shift shaft. Slide these arms and the shift rail along the shift shaft to a position so that the shift latch lever works freely about its shoulder screw and the shift solenoid plunger does not bind in its casing. Set the top surface of this shift rail parallel with the shift shaft and tighten set screws in the two arms on the shift shaft.

43. **Shift Operating Arm Stop Screw (Rear).** With the carriage roller (Fig. 10) resting on the shift rail, adjust the rear stop screw so that the printing in the unshifted position will be of equal depth at the top and bottom of all characters; that is, it shall be neither too light nor too heavy on top or bottom. When this point is reached, lock the stop screw with its check nut.

44. **Hook for Shift and Latch Lever.** Locate the adjustable hook on the shift latch lever (Fig. 10) by means of its clamp screws so that the play between it is as small as possible consistent with proper shifting of the carriage.

45. **Shift Latch.** Adjust shift latch (Fig. 10) so that when the carriage is shifted and the shift operating arm rests against the shift latch the upper case characters are on a line with the lower case characters.

46. **Shift Operating Arm Stop Screw (Front).** Adjust the front stop screw for the shift operating arm (Fig. 10) so that the carriage will not overthrow and cause the first character, after the carriage is shifted, to be printed lower than the characters on either side. It should, of course, be far enough from the shift latch to insure the proper latching up of the shift operating arm when the shift signal is received.

47. **Shift Solenoid Plunger Travel.** The stop nut at the top of the shift solenoid plunger (Fig. 10) shall be so located as to allow the plunger to come to rest on the leather washer before the vertical leg of the shift operating arm strikes the front stop screw but not until after it presses the shift latch. The front stop screw must not be required to oppose the magnetic pull on the solenoid plunger but only to stop the momentum of the carriage. Apply current to the shift solenoid. Bring up the shift solenoid lower core until it bears on the bottom of the solenoid plunger. Then back off one-half turn. Lock it in this position with its check nut.

48. **Manual Shift Contact.** The manual shift contacts at the front left side of the printer (Fig. 10) shall normally be open about .050 inch. A force of not less than 40 grams on the button projecting from the side frame shall be required to close these contact points.

49. **Bell Contact.** Adjust the location of the bell contact lever (Fig. 11) so that with the carriage in its shifted position an opening of 1/32 inch will exist between the hooked end of the contact lever and the beveled fibre block on the lower end of the bell contact spring.

50. **Ribbon Shield.** Tighten the clamp screw on the ribbon shift arm (Fig. 7), thus fastening the arm to the shift shaft in such a position that the ribbon shield is carried so as to allow the type to strike the upper half of the ribbon and so that in its normal position the upper edge of the ribbon is on a line with the bottom edge of the line of printing. This is essential in order that the printing may be entirely visible.

51. **Ribbon Feed Reversing Bar Lock Spring.** Set the ribbon feed reversing bar lock spring (Fig. 12) in the right hand notch on the ribbon feed reversing bar so that the distance from the center of the pin at the top of the reversing arm to the front edge of the right lug on the ribbon feed reversing lever equals the distance from this same pin to the left hand lug on the reversing lever when the reversing bar is moved to the right and the lock spring rests in the left hand notch.

52. **Ribbon Feed Reversing Arm and Ribbon Feed Operating Lever.** Tighten the set screws in the ribbon feed reversing arm (Fig. 12) and in the ribbon operating lever stop so that the ribbon reversing arm and the ribbon feed operating lever are approximately in a straight line.

53. **Ribbon Feed Trip Levers.** Loosen the set screws holding the ribbon feed trip levers (Fig. 12). Swing the ribbon feed reversing lever to the position shown. Then take the ribbon feed reverse finger and move it also to the approximate position shown; that is, with the right half of the hooked end on the finger just in front of but not touching the right hand lug on the reversing lever. While holding the ribbon feed reverse finger in this position bring the right ribbon spool head to bearing on the side of the right ribbon spool head and fasten it to its trip shaft. Swing the ribbon feed reversing lever to its opposite position. Move the ribbon feed reverse finger until the left half of the hooked end is directly in front of but not touching the left hand lug on reverse lever. Now bring the left ribbon feed trip lever to bearing on the side of the left ribbon spool head and fasten it to its trip shaft.

54. **Stop Collars and Ribbon Spool Heads.** Adjust the collars at the lower ends of the spool shafts (Fig. 12) so as to bear on the lock washers and produce sufficient friction to prevent either shaft from rotating too freely. Fasten the ribbon spool heads to the spool shafts so that when the ribbon spools are mounted on the heads the ribbon will not interfere with the printer top covers.

55. **Ribbon Feed Pawl Supports.** Adjust the ribbon feed pawl supports (Fig. 12) so that when the ribbon mechanism is in its normal position the points of both pawls of one set are in full engagement with the teeth of their ratchet. When this is done there will be no back lash in the active ratchet and the feeding pawl will have its maximum effect.

56. **Ribbon Feed Trip Shaft Locking Collar.** Set the ribbon feed trip shaft locking collar (Fig. 12) on the left ribbon feed trip shaft so that as the ribbon reversing mechanism is swung from one stop to the other the projection on the collar will have approximately equal rotations on either side of the detent spring.

57. **Ribbon Feed Stop Screw.** A stop screw limits the stroke of the ribbon feed pawls by striking the rear edge of the ribbon feed reversing arm (Fig. 12). It shall be set so as to allow the pawl points to move over approximately one and one-half ratchet teeth each time the printing solenoid operates.

58. **Cable Form.** For convenience in wiring printers in which the cable form must be replaced, Figure 15, which shows the cable form, is included.

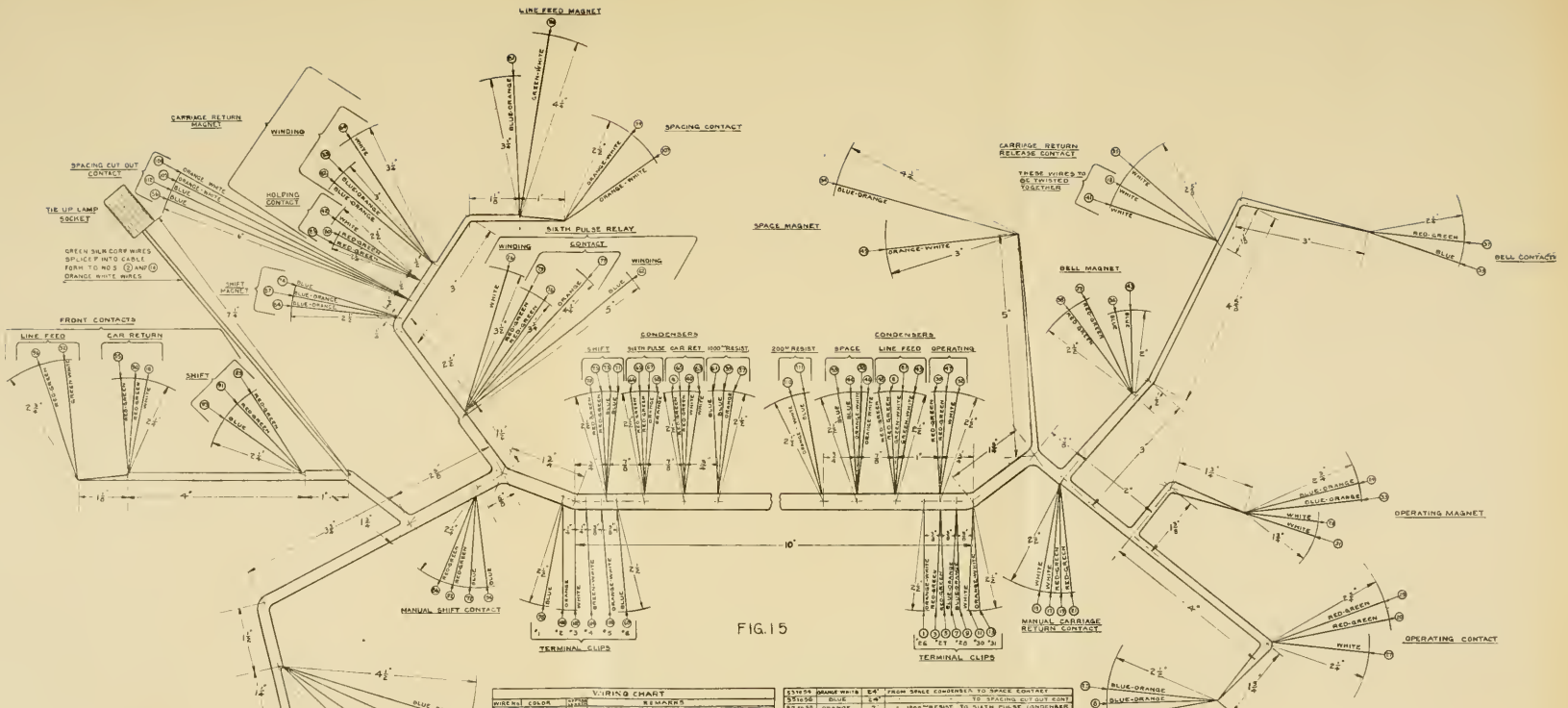



FIG. 15

## WIRING CHART

| WIRE No. | COLOR | CABLE LENGTH | REMARKS |
|---|---|---|---|
| 1 TO 2 | ORANGE WHITE | 15" | FROM TERMINAL "F" TO TIE UP LAMP |
| 3 TO 4 | RED GREEN | 11" | " "E" TO CARRIAGE RETURN CONDENSER |
| 5 TO 6 | " | 8" | " " LINE FEED CONDENSER |
| 7 TO 8 | BLUE-ORANGE | 18" | " "ED" " SIXTH PULSE CONTACT |
| 9 TO 10 | " | 6" | " " " " MAGNET |
| 11 TO 12 | WHITE | 27" | " "30" " SELECTING MAGNET COIL |
| 13 TO 14 | ORANGE WHITE | 15" | " "31" " TIE UP LAMP |
| 15 TO 16 | WHITE | 5.5" | " MANUAL CAR RETURN CONT TO FRONT CAR RET CONT |
| 17 TO 18 | " | 18" | " " " " " CAR RET RELEASE CONT |
| 19 TO 20 | RED-GREEN | 16" | " " " " " OPERATING CONTACT |
| 21 TO 22 | " | 8" | " " " " " BELL MAGNET |
| 23 TO 24 | BLUE ORANGE | 15" | " SIXTH PULSE CONTACT TO OPERATING MAGNET |
| 25 TO 26 | WHITE | 39" | " " " SIXTH PULSE RELAY |
| 27 TO 28 | " | 16" | " OPERATING CONTACT TO OPERATING MAGNET |
| 29 TO 30 | RED-GREEN | 15" | " " " " CONDENSER |
| 31 TO 32 | WHITE | 13" | " " MAGNET " " |
| 33 TO 34 | BLUE-ORANGE | 18" | " " " " SPACE MAGNET |
| 35 TO 36 | BLUE | 18" | " BELL CONTACT TO BELL MAGNET |
| 37 TO 38 | RED-GREEN | 13" | " " " " " |
| 38 TO 40 | WHITE | 52" | " CAR RET. RELEASE CONT TO CAR. RET. COND |
| 41 TO 42 | " | 51" | " " " " TO CAR RET MAG. HOLD CONT |
| 43 TO 44 | BLUE | 15" | " BELL MAGNET TO SPACE CONDENSER |
| 45 TO 46 | ORANGE WHITE | 15" | " SPACE MAGNET " " " " |
| 47 TO 48 | RED-GREEN | 8" | " OPER. COND. TO LINE FEED CONDENSER |
| 49 TO 50 | GREEN-WHITE | 5.5" | " LINE FEED COND TO WIRE FEED MAGNET |
| 51 TO 52 | " | 5.5" | " " " " " CONTACT |
| 53 TO 54 | ORANGE WHITE | 24" | FROM SPACE CONDENSER TO SPACE CONTACT |
| 55 TO 56 | BLUE | 24" | " " " TO SPACING CUT OUT CONT. |
| 57 TO 58 | ORANGE | 9" | " 1000 OHM RESIST TO SIXTH PULSE CONDENSER |
| 59 TO 60 | BLUE | 8" | " " " TERMINAL "L" |
| 61 TO 62 | " | 19" | " " " " " SIXTH PULSE RELAY |
| 63 TO 64 | WHITE | 16" | " CAR RET COND TO CAR RETURN MAG WINDING |
| 65 TO 66 | RED-GREEN | 6" | " " " " SIXTH PULSE CONDENSER |
| 67 TO 68 | ORANGE | 10" | " SIXTH PULSE COND. TO SIXTH PULSE MAGNET |
| 69 TO 70 | RED-GREEN | 6" | " " " TO SHIFT CONDENSER |
| 71 TO 72 | BLUE | 8" | " SHIFT COND TO MANUAL SHIFT CONTACT |
| 73 TO 74 | " | 13" | " " " " SHIFT MAGNET |
| 75 TO 76 | RED-GREEN | 10" | " " " " SIXTH PULSE RELAY |
| 77 TO 78 | ORANGE | 10" | " SIXTH PULSE RELAY TO SIXTH PULSE MAGNET |
| 79 TO 80 | RED-GREEN | 13" | " CAR RET MAG. HOLD CONT |
| 81 TO 82 | BLUE-ORANGE | 9" | " LINE FEED MAGNET TO CAR RETURN MAG WINDING |
| 83 TO 84 | " | 7" | " CAR RET MAG WINDING TO SHIFT MAGNET |
| 85 TO 86 | RED-GREEN | 11" | " CAR " " HOLD CONT TO MAN SHIFT CONT |
| 87 TO 88 | BLUE ORANGE | 20" | " SHIFT MAGNET TO SIXTH PULSE MAGNET |
| 89 TO 90 | RED GREEN | 5" | " FRONT SHIFT CONTACT TO FRONT CAR RET CONT |
| 91 TO 92 | " " | 9" | " " " " " MANUAL SHIFT CONT |
| 93 TO 94 | BLUE | 9" | " " " " " |
| 95 TO 96 | RED GREEN | 9" | " " CAR RET CONT TO FRONT LINE FEED CONT. |
| 97 TO 98 | BLUE | 13" | " SELECTING MAGNET #1 TO TERMINAL "L" |
| 99 TO 100 | ORANGE | 15" | " " " " " #2 " " #6 |
| 101 TO 102 | WHITE | 26" | " " " " " #3 " " #3 |
| 103 TO 104 | GREEN-WHITE | 21" | " " " " " #4 " " #6 |
| 105 TO 106 | ORANGE WHITE | 63" | " " " " " #5 " " #5 |
| 107 TO 108 | " " | 13" | " SPACE CONTACT TO SPACING CUT OUT CONTACT |
| 108 TO 110 | " " | 18" | " SPACING CUT OUT CONTACT TO 200 OHM RESISTANCE |
| 111 TO 112 | BLUE | 24" | " 200 OHMS TO SPACING CUT OUT CONTACT |

| APPROX AMOUNT OF EACH COLOR WIRE USED IN CABLE FORM | |
|---|---|
| COLOR | APPROXIMATE |
| ORANGE WHITE | 10'-0" |
| RED GREEN | 11'-9" |
| BLUE-ORANGE | 8'-3" |
| WHITE | 21'-9" |
| BLUE | 12'-0" |
| GREEN WHITE | 6'-0" |
| ORANGE | 5'-1" |

### CONDUCTORS TO BE USED

CONDUCTORS SHALL BE #22 EXTRA FLEXIBLE EACH COMPOSED OF 7 NO. 30 B & S. GAUGE TINNED SOFT DRAWN COPPER WIRES (.010 INCH) SPIRALLY WOUND WITH A 3/8" LAY. EACH STRANDED CONDUCTOR (7X30) SHALL HAVE ONE SERVING OF A CLOSE, EVEN WIND OF 100/1 PLY SOFT COTTON A 15 MIL. WALL OF 20% RUBBER COMPOUND, A BRAID OF CLOSELY WOVEN FLOSS SILK HAVING COLOR COMBINATIONS AS SPECIFIED ON THIS CHART AND OF SHADES TO BE APPROVED BY THE TELEGRAPH COMPANY.

### MAKE-UP OF CABLE FORM

TRUNK OF THE CABLE FORM SHALL BE LACED WITH WATER PROOF OSPREY TWINE (12 PLY WAXED) WITH A BIGHT ABOUT EVERY 3/4 AND IN ALL CASES TO HAVE A BIGHT AT A POINT OF JUNCTION WHERE LEADING OUT WIRES BRANCH FROM CABLE. AFTER THE CABLE HAS BEEN COMPLETELY FORMED IT IS TO BE GIVEN ONE COAT OF WHITE SHELLAC, SMOOTHLY APPLIED AND WITHOUT EXCESSIVE RUNS. ALL WIRES SHALL BE SKINNED 1/4 FROM ENDS AND ENDS SHALL BE TWISTED AND TINNED.
LEADS OF LINE COLOR BRANCHING FROM A COMMON POINT IN THE CABLE TRUNK SHALL BE TWISTED EXCEPT WHERE NOTED, THE SKINNED ENDS OF THESE LEADS SHALL BE TWISTED TOGETHER AND SOLDERED, ALL OTHER LEADS SHALL BE SINGLE.

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 6

AUTO CONTROL 1-A

These Specifications are the property of the Western Union Telegraph Company and shall not be published.

CONTENTS


| Subject | Paragraph |
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| OBJECT OF THE AUTO CONTROL | 3 |
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| CIRCUITS CONTROLLED BY THE AUTO CONTROL | 7 |
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| Position of Cams for Bell | 16 |
| Position of Cams for Letters | 17 |
| MEANING OF THE BELL SIGNALS | 20 |
| AUTOMATIC STOP | 21 |


SPECIFICATIONS INCLUDED: None.

PHOTOGRAPHS AND DRAWINGS:

| Figure No. | Drawing No. | Title |
|---|---|---|
| 1 | Photograph | Auto Control 1-A. |
| 2 | 22430- -2 | Auto Control 1-A Mechanism. |
| 3 | 22431- -1 | Auto Control 1-A Circuit Diagram. |
| 4 | 4532- -1 | Auto Control Cam Brush Position Theory. |
| 5 | 22432- -7 | Auto Control 1-A Theory of Operation. |

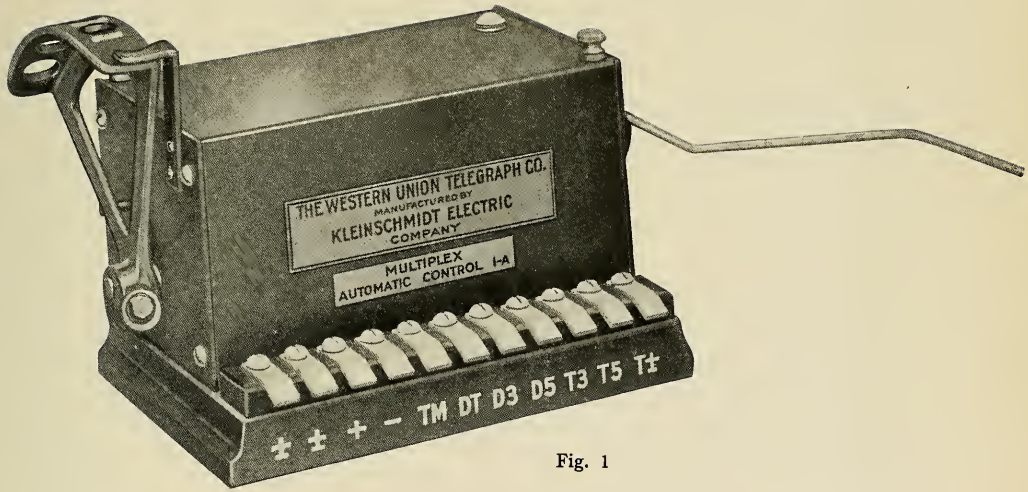

THE WESTERN UNION TELEGRAPH CO.
MANUFACTURED BY
KLEINSCHMIDT ELECTRIC
COMPANY
MULTIPLEX
AUTOMATIC CONTROL I-A
± ± + − TM DT D3 D5 T3 T5 T±

Fig. 1

## MULTIPLEX AUTO CONTROL 1-A

1. From our description of the printer we have learned that a signal bell is provided and so connected that it will ring once every time the signal combinations representing successively FIG, J, LTRS are sent to the printer.

2. This combination of signals could be accomplished by punching the desired code combination in a slip and running it through the transmitter, but in order to do this it would be necessary to remove the regular message tape from the transmitter, run the punched signal slip and then replace the regular message tape, which must be returned to the transmitter and started at the exact place, or combination, where it was stopped before running the signal slip. This would be necessary so as not to mutilate the message on the distant printer which was stopped in order to send the signal.

3. To eliminate the delay and care required for signaling in the above manner an instrument known as the "Auto Control" has been devised and constructed to work in conjunction with the transmitter and to do the required signaling automatically.

4. It consists essentially of a system of cams mounted on a shaft, the rotary motion of which is controlled by a hand lever, spring and magnet. When the hand lever or finger wheel of the apparatus is operated the auto control circuits and mechanism are automatically substituted for those of the transmitter. The cams cause three sets of contacts to open and close in such a sequence that the impulses representing FIGS, BELL and LTRS are sent to the line once every one-fifth revolution of the cam shaft. During the operation of the auto control the transmitter is automatically kept locked in the spacing position. The tape motion is, of course, arrested, but the tape remains in the transmitter ready to resume its motion when the signal sent by the auto control is completed.

5. Figure 2 shows a perspective sketch of the apparatus. The shaft has been somewhat elongated for the sake of clearness. If the finger is inserted in the hole on the finger wheel marked "Start" and the finger wheel rotated until the finger stops against the finger stop, the ratchet shaft is rotated one notch of the ratchet. The large gear is **not** attached to the ratchet shaft but turns on it freely. One end of the main spring is attached to the ratchet shaft, the other to a fixed support. If the finger wheel is now released the main spring will tend to return the ratchet shaft to its original position. It is not free to rotate, however, because the gear retainer causes the large gear to follow the ratchet shaft, which in turn tends to rotate the cam shaft. This shaft is prevented from rotating by the armature escapement pawl on the magnet armature.

6. When the finger wheel was pulled back, the main contact operating lever released the pressure on the tongue of the main contacts and allowed it to fall back against its back contact. This causes the circuit which normally operates the transmitter magnet to be transferred to the auto control magnet. Each revolution of the distributor brushes therefore causes this magnet to attract and release its armature. In so doing it causes the pawl to release the escapement wheel one tooth for each revolution of the distributor brushes. The cams then set the contacts in a definite position for each revolution of the distributor brushes. The first revolution following the operation of the finger wheel sets the cams so that FIG is sent; the second, BELL; the third, LTRS; and the fourth restores the cams to their normal position and the main contact operating lever then pushes the tongue of this contact against its front contact again and thus restores the circuit to the transmitter magnet.

7. Let us now refer to Figure 3, which shows the electrical circuits of the auto control and its relationship to the transmitter and distributor, and trace the transfer of the local operating circuit from the transmitter magnet to the auto control magnet.

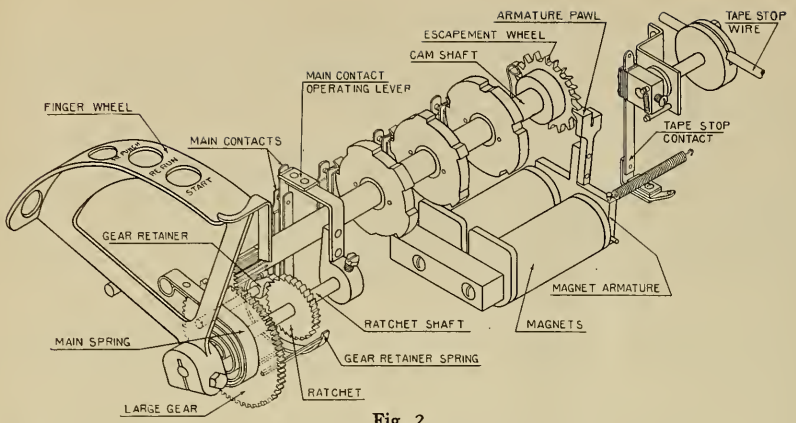



Fig. 2

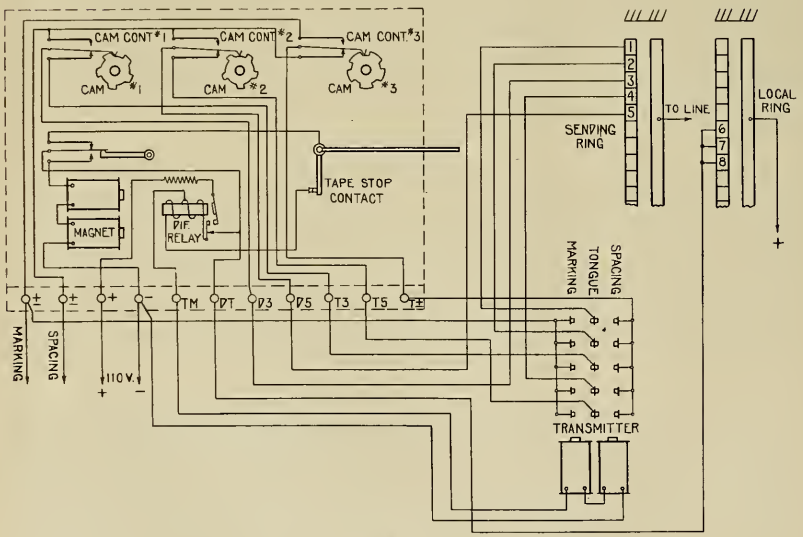



Fig. 3

8. When the auto control is in its normal position as shown, the circuit from the positive battery on the solid local ring on the distributor runs through the local brush, the local operating segment, binding post DT on the auto control, to both end terminals on the differential relay in the auto control. The path to the right hand terminal of the relay goes through the relay contacts; the path to the left hand terminal goes through the tongue and upper contact of the main contacts; the lever and contact of the auto stop wire to the left hand terminal. Since the resistance of these two paths is equal,

the current divides equally between the two and passes out at the terminal connected to the center of the winding. From that point the circuit passes through binding post TM of the auto control and the coils of the transmitter magnet to negative battery on the fourth binding post. Since the relay is differential and the current through the two branches equal, the relay is not operated by impulses sent through this normal circuit

9. When the auto control is operated, however, the tongue of the main contact transfers its connection to the lower contact and in so doing opens the path to the left hand terminal of the differential relay and connects the circuit from the local ring to one terminal of the magnet in the auto control. The other terminal is connected to negative battery on binding post 4. As the local brushes now pass over the local operating segment an impulse is sent to the auto control magnet, thus operating the escapement on the ratchet and permitting the cams to rotate as already described. At the same time an impulse is sent to the transmitter in the same manner as before, except that the impulse now passes through only one of the coils on the differential relay. This impulse operates the transmitter magnet and also the differential relay. When the relay closes, a locking circuit is established from positive battery on binding post 3 through the resistance unit, the contacts of the differential relay, one coil of this relay, the transmitter magnet to negative battery on binding post 4. This locking circuit holds both the relay and transmitter magnet closed until the auto control mechanism has returned to normal. Each impulse from the distributor now operates only the magnet in the auto control, thus allowing its mechanism to return to normal one step or tooth on the cam shaft ratchet for each revolution of the distributor brushes. When it finally reaches its normal position the main contacts are restored to their normal position and the current to the transmitter magnet is again equally divided between the two coils on the differential relay, which releases the relay and restores the transmitter circuit to normal.

10. In the foregoing we have shown only how the control circuits of the auto control operated. We now must see how the operation of the cams and contacts serves to send the combinations representing FIG, BELL and LTRS to the line. In conjunction with Figure 3 let us refer also to Figure 4, which shows the cams, surfaces developed and indicates properly their relationship to the contacts.

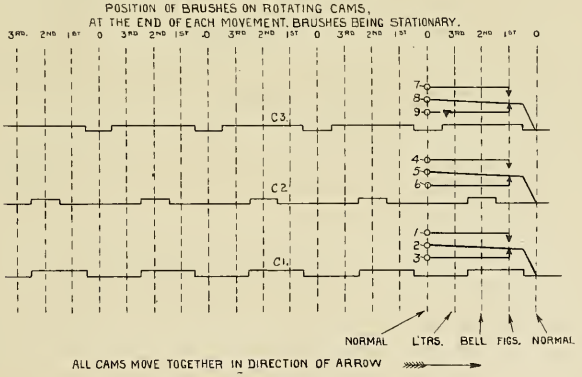



Fig. 4

11. If we trace the connections on Fig. 3 we find that segments 1, 2 and 4 of the sending ring are connected direct to the corresponding transmitter tongues, but that segments 3 and 5 are connected to the tongues of cam contacts 1 and 2 respectively. The lower contacts of these cam contacts are in turn connected to the transmitter tongues so that when the auto control is in its normal position segments 3 and 5 also are connected to their corresponding transmitter tongues.

12. The upper contacts of these cam contacts are connected to spacing battery so that if the tongues are moved against these contacts spacing battery is connected to segments 3 and 5, regardless of the position of the transmitter tongues.

13. The tongue of the third set of cam contacts is connected to the spacing contacts of the transmitter. The lower contact is connected to spacing battery. When the auto control is in its normal position, spacing battery for the transmitter is supplied through this circuit. The upper contact is connected to marking battery. If the cams are made to move the tongue of these cam contacts into contact with the upper contact, **marking** battery is thereby placed on the **spacing** contacts on the transmitter.

14. We have previously learned that the transmitter magnet is energized and locked in when the auto control is operated, so that the transmitter tongues are held against their spacing contacts while the auto control cams are rotating.

15. Let us now assume that the distributor local brushes have passed over the local operating segment once since the auto control finger wheel was released. The cams will then be in what might be called the first position. Referring to Figure 4 we see that in this position cam contacts 1 and 3 have now been operated by their cams so that their tongues are on contact with the upper contact. Cam contact No. 3 therefore supplies marking battery to segments 1, 2, 4 and 5, which are connected to the tongues of the transmitter. The third segment is connected to spacing battery on the upper contact of No. 1 cam contact. As the sending brush passes over these segments, marking battery is sent to the line on segments 1 and 2, spacing battery on 3, marking on 4 and 5. This combination, we have already learned, is the one which represents the FIGS combination and causes the printer shift magnet to operate.

16. When the auto control magnet is again operated by the local 6th pulse the cams are rotated so that position 2 is under the tips of the tongues. All three cam contact tongues are now making contact with their upper contacts. Segments 1, 2, 3 and 4 are connected exactly as for the first position, but segment 5 is now disconnected from the marking battery on the fifth tongue of the transmitter and connected direct to spacing battery by No. 2 cam contact. Marking battery is therefore sent to the line by segments 1 and 2, spacing by 3, marking by 4 and spacing by 5. This combination represents the letter "J" or BELL.

17. The next step of the cams moves them to position 3, in which position Nos. 1 and 2 cam contacts have been restored to their normal positions, thus connecting segments 3 and 5 to their corresponding transmitter tongues. Since No. 3 cam contacts still supply marking battery to the spacing contacts on the transmitter, all segments now send marking battery to the line. This represents the LTRS signal.

18. The next step of the cam restores the contacts to their normal position, also restores the main contacts to normal, which restores the normal circuit through the auto control relay as already described.

19. To cause the auto control to send the signal combination representing FIG, BELL and LTRS once, the cam shaft rotates through one-fifth of a revolution. Should we wish to strike the bell twice, we may insert the finger in the second hole on the finger wheel and then pull it back to the stop. The only difference in the operation is that the cams will now be permitted to rotate through two-fifths of a revolution before the main contacts restore the circuits to normal again. To ring three times we use finger hole No. 3, and so on, five being the maximum times the bell can be successively operated by the auto control.

20. The bell signals have been arbitrarily chosen as follows:

One bell, **Start.** This signifies that the receiving operator is ready to receive and the sending operator therefore should start tape through the transmitter. Two bells, **Rerun.** This requests the sending operator to take the tape out of the transmitter and start it again at the beginning of the message which was passing through the transmitter at the time the bell signal was operated. Three bells, **Repunch.** This informs the sending operator that there is an error in the punched tape which requires that a new

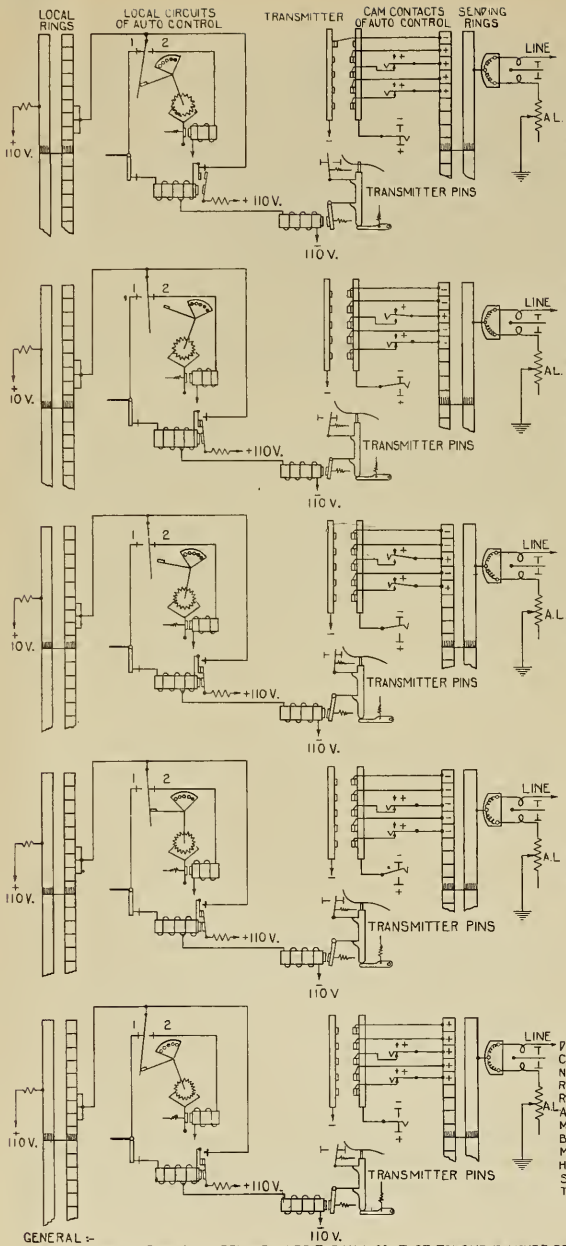
tape be prepared. Four bells, **Stop.** Signal for the operator to stop the tape going through the transmitter. Five bells, **Plant.** This signifies that an automatic chief is wanted and the operator is instructed to advise the supervisor to this effect. It is possible to provide other signals by combining in various ways the five described.

**21.** In addition to the function of sending bell signals as already described, the auto control performs another important function. It acts as an automatic stopping device for the transmitter when the tape for transmission is not being prepared by the operator as fast as the transmitter can take it. When the auto control and transmitter are properly located in their respective places on the operating table the tape passes out of the perforator at a point just a few inches to the right of the transmitter and is made to pass under the tape stop wire on the auto control before being inserted in the transmitter.

**22.** This wire is connected to a short shaft the other end of which carries a contact lever. In its normal position this contact, which is connected in series with one coil of the differential auto control relay, is closed. If the sending operator stops perforating, the tape continues feeding into the transmitter until it begins to pull taut between the perforator and transmitter. As it begins to straighten out it lifts the tape stop wire which in turn rotates its shaft and opens the contact.

**23.** If we trace the circuit on Figure 3 we see that this will open one coil of the differential relay, thus causing this relay to operate. In so doing it causes the transmitter magnet to remain energized as has already been described. Since the auto control main contacts have not been disturbed, however, the path to the auto control magnet is not closed hence; neither the auto control nor the transmitter can operate. The distributor therefore simply sends spacing current to the line for that channel until the operator again prepares tape for transmission. The tension on the tape is released as the operator again starts its preparation, which permits the arm to fall and close the contact. The de-energization of the relay is thus effected, which in turn starts the transmitter into operation again.

**24.** Figure 5 summarizes the auto control operation theory. This diagram is self-explanatory.


LOCAL RINGS
LOCAL CIRCUITS OF AUTO CONTROL
TRANSMITTER
CAM CONTACTS OF AUTO CONTROL
SENDING RINGS
LINE
A.L.
110 V.
+110 V.
TRANSMITTER PINS
A
AUTO CONTROL NORMAL-LOCAL IMPULSE OPERATES TRANSMITTER MAGNET THRU BOTH WINDINGS OF THE DIFFERENTIAL CONTROL RELAY, NEITHER RELAY NOR AUTO CONTROL MAGNET OPERATE. LETTER "E" SHOWN SET UP IN TRANSMITTER TAPE.
B
FINGER WHEEL PULLED AND RELEASED. ONE WINDING OF DIFFERENTIAL RELAY OPENED AT MAIN CONTACT-NEXT LOCAL IMPULSE ENERGIZES AUTO CONTROL MAGNET AND OPERATES MAGNET OF TRANSMITTER THRU ONE WINDING OF DIFFERENTIAL RELAY-RELAY AND TRANSMITTER MAGNET THEN LOCK UP-TAPE FED TO NEXT LETTER READY TO BE TRANSMITTED WHEN TRANSMITTER IS RELEASED. TRANSMITTER MAGNET IS NOW DISCONNECTED FROM AND THE AUTO CONTROL MAGNET CONNECTED TO THE LOCAL IMPULSE CIRCUIT AND THE LOCAL IMPULSE ENERGIZES AUTO CONTROL MAGNET AND OPERATES ESCAPEMENT ON ATTRACTION AND RELEASE OF ARMATURE, WHICH SETS CAM CONTACTS AS SHOWN-SENDING BRUSH SENDS THE SET UP SIGNAL TO LINE, RESULT-"FIGURES."
C
AUTO CONTROL MAGNET CIRCUITS SAME AS AT B-NEXT LOCAL IMPULSE CAUSES ESCAPEMENT TO OPERATE AGAIN WHICH SETS CAM CONTACTS AS SHOWN-SENDING BRUSH SENDS OUT SET-UP SIGNAL TO LINE, RESULT-"BELL".
D
AUTO CONTROL MAGNET CIRCUITS SAME AS AT B&C-NEXT LOCAL IMPULSE CAUSES ESCAPEMENT TO OPERATE AGAIN WHICH SETS CAM CONTACTS AS SHOWN-SENDING BRUSH SENDS OUT SET-UP SIGNAL TO LINE, RESULT-"LETTERS."
E
AUTO CONTROL ESCAPEMENT HAS NOW RUN DOWN-A.C. MAGNET NOW OUT OF CIRCUIT-MAIN CONTACT IS CLOSED-NEXT LOCAL IMPULSE NEUTRALIZES LOCKING CURRENT IN DIFFERENTIAL RELAY RESTORING DIFFERENTIAL CONDITION OF RELAY-AUTO CONTROL IS NOW NORMAL AGAIN. AS LOCAL BRUSH LEAVES SEGMENT, THE TRANSMITTER PINS RISE THRU THE TAPE AND SENDING BRUSH SENDS WHATEVER SIGNAL IN THE TAPE MAY BE OPPOSITE THE PINS WHEN AUTO CONTROL HAS FINISHED ITS OPERATION. CONDITION IS THEN SAME AS AT "A" EXCEPT THAT A CHARACTER OTHER THAN "E" MAY BE SET-UP IN TAPE.

GENERAL :-

WHEN THE FINGER WHEEL IS PULLED THE MAIN CONTACT TONGUE IS MOVED FROM CONTACT 1 TO CONTACT 2. WHEN THE FINGER WHEEL IS RELEASED THE ESCAPEMENT CAUSES THE CAM SHAFT TO ROTATE THE CAMS. ONE CAM CONTACT IMMEDIATELY PUTS MARKING BATTERY ON THE SPACING BUS BAR OF THE TRANSMITTER AGAINST WHICH THE TRANSMITTER TONGUES ARE CAUSED TO REST. THIS BAR REMAINS MARKING UNTIL THE AUTO CONTROL OPERATION IS FINISHED. THE OTHER TWO CAM CONTACTS CHANGE DIRECTLY, AS REQUIRED, THE POLARITY OF THE SENDING SEGMENTS 3 AND 5. THE VARIOUS CIRCUIT CHANGES WHICH TAKE PLACE IN THE OPERATION ARE ILLUSTRATED IN THE ABOVE DIAGRAMS. POLARITIES ON SENDING SEGMENTS AND CAM CONTACTS APPLY TO A&C CHANNELS.

**Fig. 5**

## ADJUSTMENTS

1. **General.** Before adjusting, the auto control shall be thoroughly cleaned, examined for mechanical or electrical defects, and a thin film of oil applied to all bearing surfaces.

2. **Cam Contact Tongue Position.** Set the contact tongue so that the apex of the V is about .020 inch from the low part of the cam.

3. **Cam Contact Tongue Pressure.** Adjust each tongue so that there is a normal pressure of not more than 75 grams nor less than 50 grams pressure against the front or normally closed contacts to be measured at the point of contact.

4. **Back Cam Contact.** Adjust the back contacts so that they lie snugly against their back stops with a pressure of from 50 to 75 grams and so that there is a contact gap of not more than .020 inch nor less than .010 inch between the back contact and the tongue contact.

5. **Front Cam Contact.** The contact pressure of the normally closed contact (front contact) on the main contacts against the tongue shall be not more than 75 grams nor less than 50 grams.

6. **Main Spring Tension.** Adjust the tension of the main spring so that a force of 450 to 550 grams when applied in the first finger hole will just move the finger wheel.

7. **Magnet Armature Back Stop.** Set the magnet armature back stop so that the full face of the escapement wheel tooth just rests on the top tooth of the escapement pawl.

8. **Finger Wheel Position.** Set the finger wheel against its stop pin.

9. **Safety Spring Position.** Set the safety or jockey spring so that it fits properly between two teeth of the escapement wheel.

10. **Tape Stop Wire.** Set the tape stop wire so that it extends 1/8 inch minimum and 3/16 inch maximum beyond its upper stop pin and so that it shall have a clearance of 1/32 inch minimum and 1/16 inch maximum between it and the pin when the tape stop contact is closed.

11. These adjustments are all made with the auto control in its normal, unoperated position. Now pull back the finger wheel and make the following adjustments:

12. **Magnet Position.** Move the magnet armature to its operated position and adjust the magnets so that the full face of the escapement wheel tooth just rests against the lower tooth of the escapement pawl.

13. **Back Contact of Main Contacts.** Adjust the back contact of the main contacts so that there is a gap of not more than .010 inch nor less than .006 inch between the tongue and the front contact.

14. **Tongue of Main Contacts.** Adjust the tongue of the main contact so that there shall be a pressure of not more than 75 grams nor less than 50 grams against the back contact.

15. **Main Contact Operating Arm.** With the magnet armature held against the magnets on its last stroke before the main contact operating arm reaches its normal position, adjust this arm so that it just touches the tongue of the main contacts. If after the arm is set the magnet armature is released, the operating arm should break from the back contact and make with the front contact with an appreciable amount of overtravel. This adjustment should be checked several times, and after completing it the adjustment of the main contact shall be rechecked.

16. **Magnet Armature Retractile Spring.** The tension of the magnet armature retractile spring when stretched to 1 3/4 inches over all shall be not more than 250 nor less than 225 grams.

17. **Tape Stop Wire Retractile Spring.** The tension of the tape stop wire retractile spring when stretched to 11/16 inch over all shall be not less than 125 nor more than 200 grams.

18. **Differential Relay.** The differential relay armature shall have a play of not more than .025 inch nor less than .020 inch. It shall operate on .120 and not on .110 ampere, when the test is made on one-half of the winding only. Both halves should be tested.

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 7

## MULTIPLEX TERMINAL SET ASSEMBLY

These Specifications are the property of the Western Union Telegraph Company and shall not be published.

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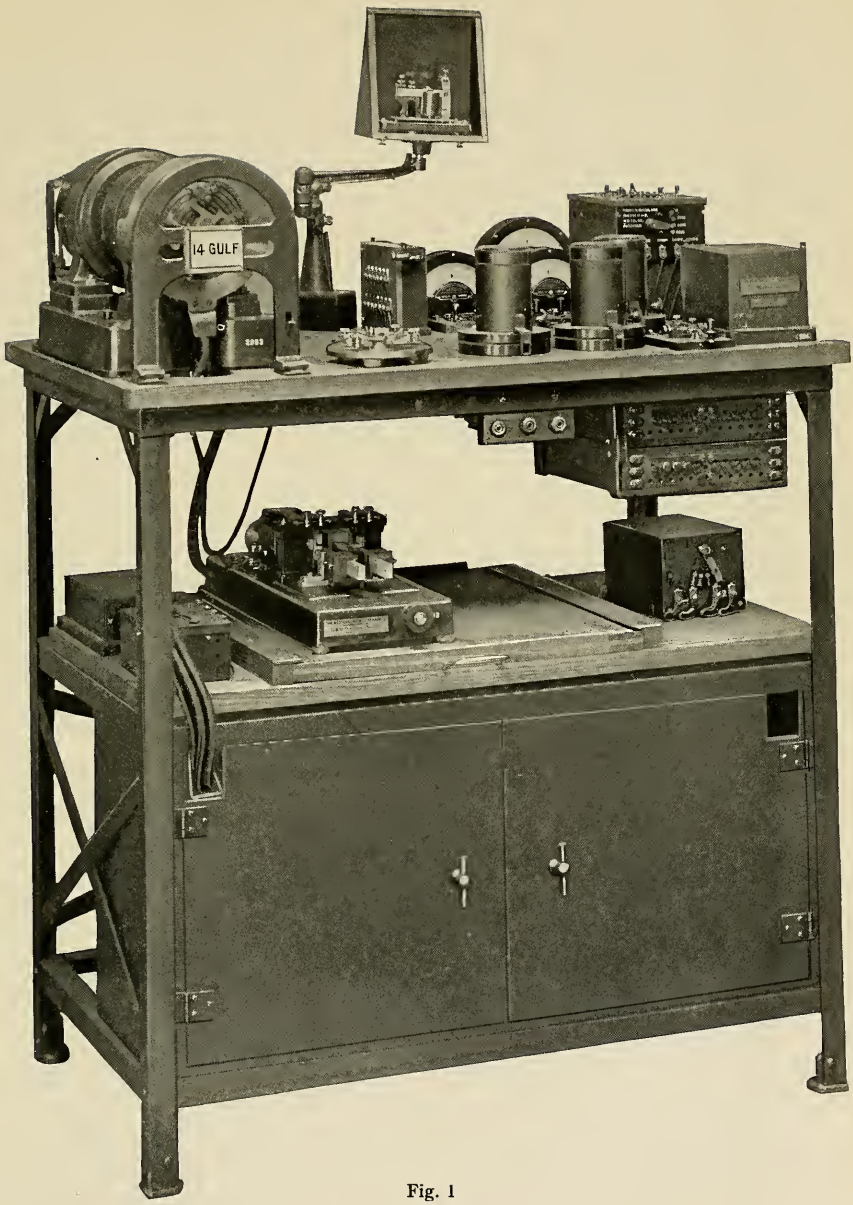



Fig. 1

## MULTIPLEX TERMINAL SET ASSEMBLY

1. In Sections two to six inclusive the apparatus used in multiplex operation were described as individual units. It is the purpose of this section to assemble these units to form multiplex terminal sets. These sets may be either of the one or two distributor type and may have from one to four channels.

2. All terminal sets require at least one each of the units described in the preceding sections. These units are mounted on standard tables built with angle iron frames and oak tops.

3. Since the four channel, single distributor set might be called the basic set, we will first completely assemble one of these sets and show how it is placed in operation and then show the modifications that are made when it is desirable to change this set to any of the other possible variations.

4. The distributor and its associated apparatus are mounted on the distributor table as shown in Figure 1. Here the driving fork, distributor and cam switch are assembled, together with all the apparatus needed for operating the circuit as a polar duplex; i. e., polarized relays, artificial line, meters and jacks for convenience in balancing and for locating troubles, anti-noise sets for reducing the inductive interference produced by the multiplex signals in adjacent telephone circuits, switches for battery and ground, etc. In the terminal box under the table, switches, fuses, connecting blocks and resistance units are located. The layout of instruments on the table top, shelf, and terminal box is shown in Figures 2 and 3. Figure 4 shows the connections between the distributor face plate segments and the plug panels. The wiring of the table is shown in Figure 5. Local battery, line potentials, line and ground connections are brought to the terminal box from the switchboard or distributing frame and power panels and connected as shown in this figure.

5. The transmitters, perforators, printers, and auto controls are assembled in channel units on standard operating tables. In addition to these multiplex units all standard operating tables are equipped with an electric time stamp and an automatic numbering machine. Separate specifications are available and should be consulted for information on these units. An operating table fully equipped is shown in Figure 6 and Figure 6-A shows the table layout.

6. Four of these channel units are required for the four channel set. They are usually placed next to and on a line with the distributor table so that they may be conveniently connected to it, but where the space available does not permit of this arrangement they may be placed in any convenient location and connected to the distributor by longer cables. When shipped to the field the operating and distributor tables are completely wired, but the connections between the operating table terminal boxes at the left hand end of each table and the distributor table terminal box must be made in the field. These connections are shown in Figure 7. For convenience the channel units are designated by the letters A, B, C, and D.

7. The operating table wiring is shown in Figure 8. On the right hand edge of this figure the proper polarities for the printer and auto control are shown. Attention is called to the fact that the A and C tables differ from the B and D tables in the location of the two local battery polarities. This difference is made necessary by the choice of marking (selecting) battery for the different channels. If negative battery were always used as selecting battery and all four channels should be left idle at the non-correcting station—i. e., all left shut off—only positive (non-selecting) battery would be sent to the line. If this condition prevailed for more than a few seconds the set would go out of synchronism, for the corrector at the correcting station can operate only when the received current reverses from positive to negative. To provide these reversals for the corrector, even when the set is idle, negative was chosen as the selecting battery for the A and C channels, and positive for the B and D channels. With this arrangement two reversals from positive to negative are sent to the line per revolution, even when all

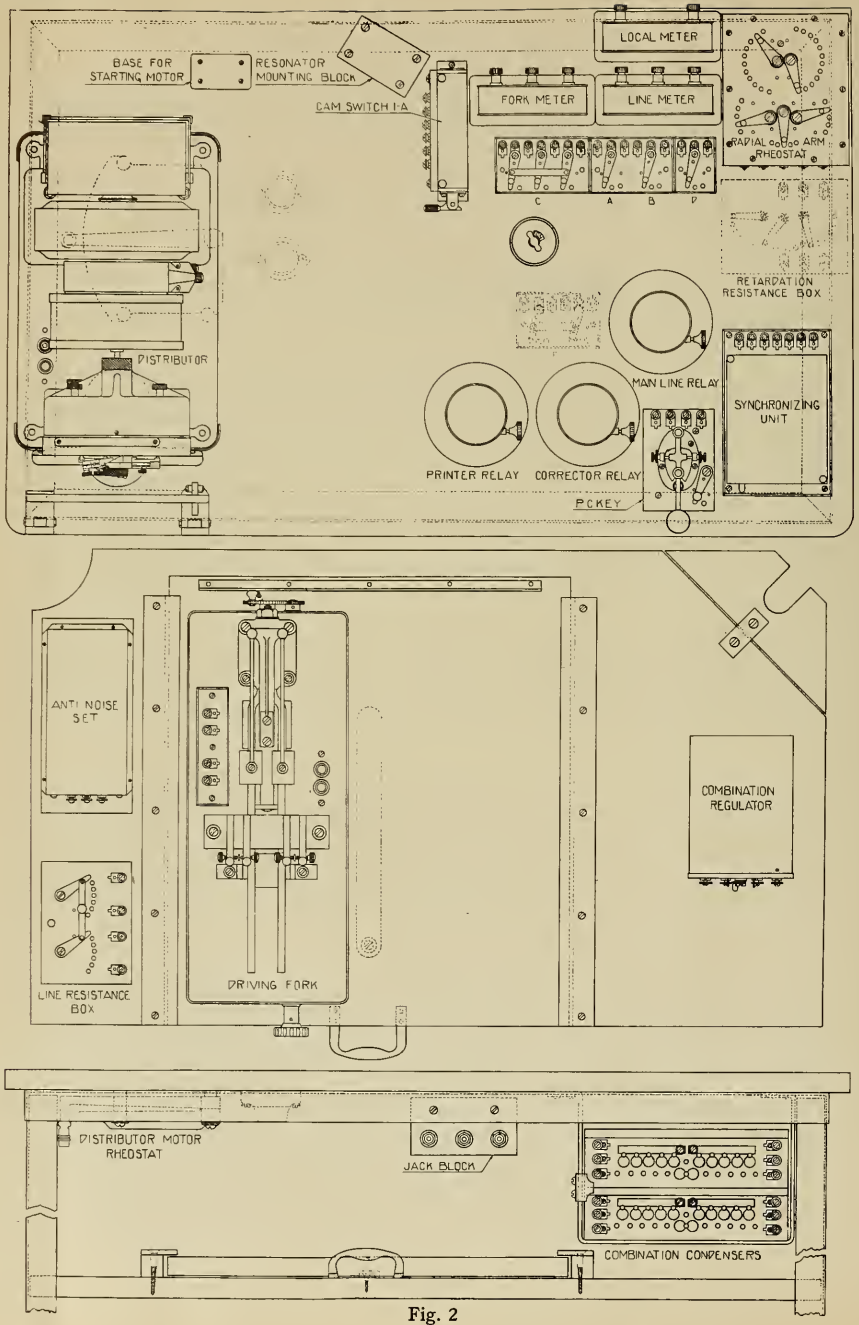

BASE FOR STARTING MOTOR
RESONATOR MOUNTING BLOCK
CAM SWITCH 1-A
LOCAL METER
FORK METER
LINE METER
RADIAL ARM RHEOSTAT
C
A
B
D
RETARDATION RESISTANCE BOX
DISTRIBUTOR
MAIN LINE RELAY
SYNCHRONIZING UNIT
PRINTER RELAY
CORRECTOR RELAY
P.C.KEY
ANTI NOISE SET
COMBINATION REGULATOR
LINE RESISTANCE BOX
DRIVING FORK
DISTRIBUTOR MOTOR RHEOSTAT
JACK BLOCK
COMBINATION CONDENSERS

Fig. 2

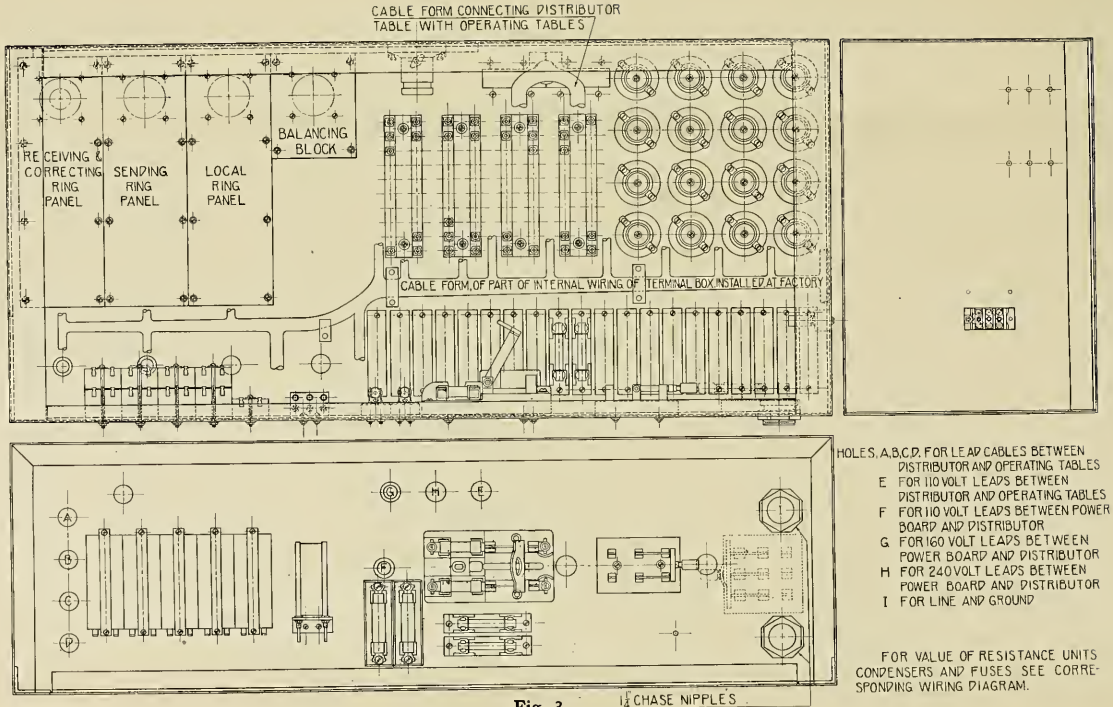

CABLE FORM CONNECTING DISTRIBUTOR TABLE WITH OPERATING TABLES
RECEIVING & CORRECTING RING PANEL
SENDING RING PANEL
LOCAL RING PANEL
BALANCING BLOCK
CABLE FORM, OF PART OF INTERNAL WIRING OF TERMINAL BOX INSTALLED AT FACTORY
HOLES, A, B, C, D, FOR LEAD CABLES BETWEEN DISTRIBUTOR AND OPERATING TABLES
E FOR 110 VOLT LEADS BETWEEN DISTRIBUTOR AND OPERATING TABLES
F FOR 110 VOLT LEADS BETWEEN POWER BOARD AND DISTRIBUTOR
G FOR 160 VOLT LEADS BETWEEN POWER BOARD AND DISTRIBUTOR
H FOR 240 VOLT LEADS BETWEEN POWER BOARD AND DISTRIBUTOR
I FOR LINE AND GROUND
FOR VALUE OF RESISTANCE UNITS CONDENSERS AND FUSES SEE CORRESPONDING WIRING DIAGRAM.
1¼ CHASE NIPPLES

**Fig. 3**

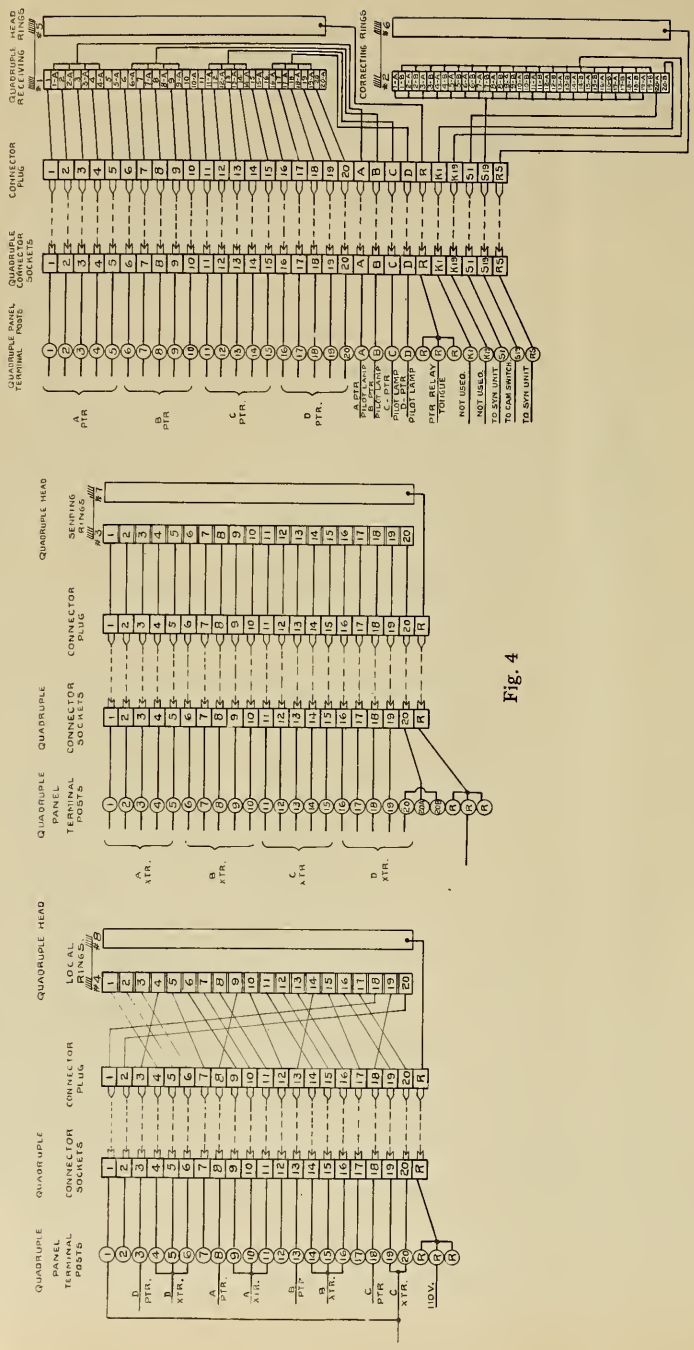

QUADRUPLE HEAD
QUADRUPLE RECEIVING RINGS
CORRECTING RINGS
CONNECTOR PLUG
QUADRUPLE CONNECTOR SOCKETS
QUADRUPLE PANEL TERMINAL POSTS
A PTR.
B PTR.
C PTR.
D PTR.
PTR. RELAY TONGUE
NOT USED
TO SYN UNIT
TO CAM SWITCH
TO SYN UNIT
SENSING RINGS
LOCAL RINGS
110 V.

Fig. 4

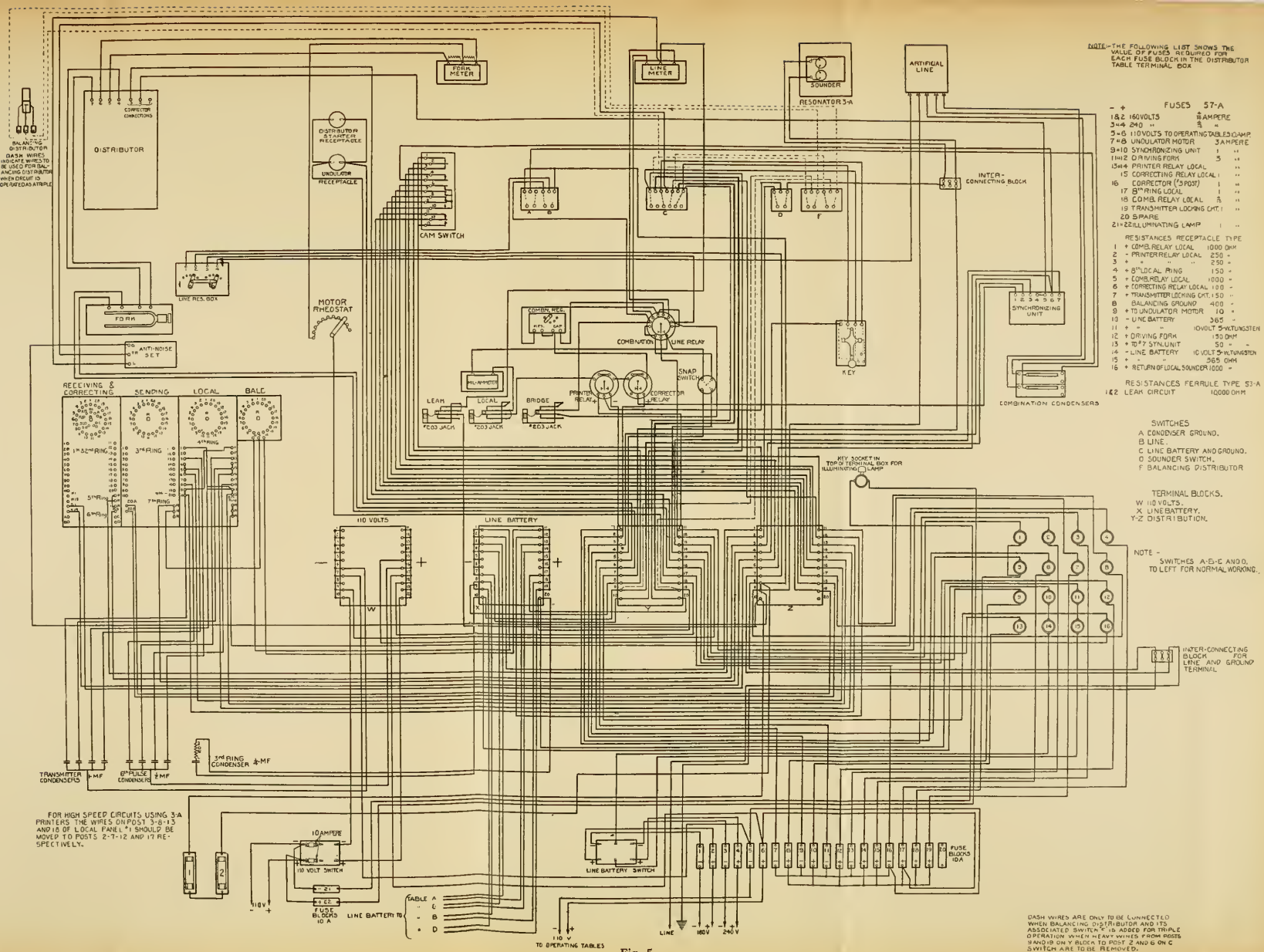

NOTE – THE FOLLOWING LIST SHOWS THE VALUE OF FUSES REQUIRED FOR EACH FUSE BLOCK IN THE DISTRIBUTOR TABLE TERMINAL BOX
FUSES 57-A
1&2 160 VOLTS ¾ AMPERE
3&4 240 " ¾ "
5–6 110 VOLTS TO OPERATING TABLES 3 AMP
7&8 UNDULATOR MOTOR 3 AMPERE
9&10 SYNCHRONIZING UNIT 1 "
11&12 DRIVING FORK 3 "
13&14 PRINTER RELAY LOCAL "
15 CORRECTING RELAY LOCAL 1 "
16 CORRECTOR (3 POST) 1 "
17 8TH RING LOCAL 1 "
18 COMB. RELAY LOCAL ¾ "
19 TRANSMITTER LOCKING CKT. 1 "
20 SPARE
21&22 ILLUMINATING LAMP 1 "
RESISTANCES RECEPTACLE TYPE
1 + COMB. RELAY LOCAL 1000 OHM
2 – PRINTER RELAY LOCAL 250 "
3 + " " 250 "
4 + 8TH LOCAL RING 150 "
5 + COMB. RELAY LOCAL 1000 "
6 + CORRECTING RELAY LOCAL 100 "
7 + TRANSMITTER LOCKING CKT. 150 "
8 BALANCING GROUND 400 "
9 + TO UNDULATOR MOTOR 10 "
10 – LINE BATTERY 365 "
11 + " " 10 VOLT 5 WATT TUNGSTEN
12 + DRIVING FORK 150 OHM
13 + TO SYN. UNIT 50 " "
14 – LINE BATTERY 10 VOLT 5 WATT TUNGSTEN
15 + " " 365 OHM
16 + RETURN OF LOCAL SOUNDER 1000 "
RESISTANCES FERRULE TYPE 53-A
1&2 LEAK CIRCUIT 10000 OHM
SWITCHES
A CONDENSER GROUND.
B LINE.
C LINE BATTERY AND GROUND.
D SOUNDER SWITCH.
F BALANCING DISTRIBUTOR
TERMINAL BLOCKS.
W 110 VOLTS.
X LINE BATTERY.
Y-Z DISTRIBUTION.
NOTE – SWITCHES A-B-C AND D, TO LEFT FOR NORMAL WORKING.
FOR HIGH SPEED CIRCUITS USING 3-A PRINTERS THE WIRES ON POST 3-8-13 AND 16 OF LOCAL PANEL "1" SHOULD BE MOVED TO POSTS 2-7-12 AND 17 RESPECTIVELY.
DASH WIRES ARE ONLY TO BE CONNECTED WHEN BALANCING DISTRIBUTOR AND ITS ASSOCIATED SWITCH "C" IS ADDED FOR TRIPLE OPERATION. WHEN HEAVY WIRES FROM POSTS 9 AND 10 ON Y BLOCK TO POST Z AND 6 ON C SWITCH ARE TO BE REMOVED.
DISTRIBUTOR
BALANCING DISTRIBUTOR
DASH WIRES INDICATE WIRES TO BE USED FOR BALANCING DISTRIBUTOR WHEN CIRCUIT IS OPERATED AS A TRIPLE
CORRECTOR CONNECTIONS
FORK METER
LINE METER
SOUNDER
RESONATOR 3-A
ARTIFICIAL LINE
DISTRIBUTOR STARTER RECEPTACLE
UNDULATOR RECEPTACLE
CAM SWITCH
INTER-CONNECTING BLOCK
LINE RES. BOX
FORK
MOTOR RHEOSTAT
ANTI-NOISE SET
COMBN. REC.
COMBINATION LINE RELAY
SNAP SWITCH
MILLIAMMETER
PRINTER RELAY
CORRECTOR RELAY
LEAK
LOCAL
BRIDGE
*203 JACK
KEY
SYNCHRONIZING UNIT
COMBINATION CONDENSERS
RECEIVING & CORRECTING
SENDING
LOCAL
BALL
1ST RING
2ND RING
3RD RING
4TH RING
5TH RING
6TH RING
7TH RING
KEY SOCKET IN TOP OF TERMINAL BOX FOR ILLUMINATING LAMP
110 VOLTS
LINE BATTERY
W
X
Y
Z
INTER-CONNECTING BLOCK FOR LINE AND GROUND TERMINAL
TRANSMITTER CONDENSERS 4 MF
8TH PULSE CONDENSERS 2 MF
3RD RING CONDENSER 4 MF
10 AMPERE
110 VOLT SWITCH
FUSE BLOCKS 10 A
LINE BATTERY TO
TABLE A
C
B
D
LINE BATTERY SWITCH
FUSE BLOCKS 10 A
110 V TO OPERATING TABLES
LINE
160 V
240 V

Fig. 5

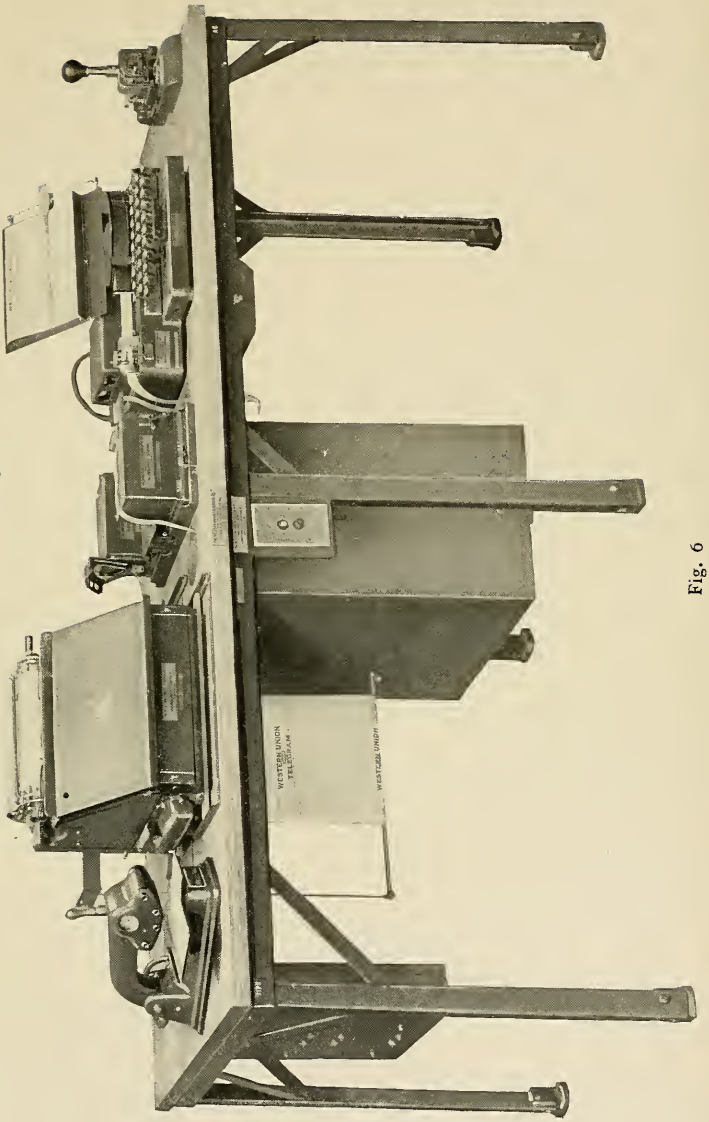



Fig. 6

transmitters are idle. The only difference in wiring necessary between the two sets of tables to take care of this arrangement is in the location of the local battery potentials shown in Figure 8.

8. All multiplex units used on the operating tables are electrically connected to the table wiring by clips so that any unit may be conveniently removed and replaced without the use of tools of any kind. These clips usually are referred to by the numbers shown in Figure 8.

9. With all four channel units in position and properly connected to the distributor table, all instruments properly adjusted and in place, and the Wheatstone relays carefully centered the set is ready for operation. Before actually starting the apparatus we must, however, decide at what operating speed we are going to work. This is determined by the constants of the circuit, the speed range of the driving fork, and the traffic requirements. The fork will give distributor speeds of from 175 to 354 revolutions per minute. Let us see what this means in terms of transmitting frequency stated either in cycles per second or words per minute, both terms being common terms for giving the speed of multiplex circuits.

10. The frequency depends upon the number of segments of the transmitting ring and the speed at which the distributor brushes rotate. In considering the quadruple distributor, if we assume that ten alternate segments of the 20 segments of the transmitting ring are connected to negative and the other ten segments connected to positive, the rotating brushes in passing over these segments will transmit the equivalent of an alternating current. For each complete revolution of the sending brushes over the face of the distributor, ten complete alternating waves or cycles will be transmitted, because the sending ring is composed of twenty segments and each segment represents a half wave. From this it will be seen that to calculate the frequency in cycles per second it is necessary only to know the speed of the brushes and the number of transmitting segments and from this calculate the frequency. In general

$$\frac{\text{R.P.M.} \times \frac{1}{2}\,S}{60} = \text{cycles per second,}$$

where S is the number of transmitting segments. One character is transmitted on each channel for each revolution of the brushes; therefore

$$\frac{\text{R.P.M.}}{6} = \text{words per minute per channel.}$$

6 being the numbers of characters usually counted as a word. It might be well to mention that for four channel circuits the frequency in cycles per second is exactly equal to the number of words per minute; for a three channel circuit the frequency in cycles per second is only three-fourths as great as the speed given in words per minute; and for a two or one channel circuit the frequency in cycles is only one-half of the number of words per minute. The relationship between the line speed in cycles per second and channel speed in words per minute is graphically shown in Figure 9.

11. Let us assume that we are going to operate at 40 words per minute per channel, which is equal to 40 cycles per second with the four channel set. Transposing the formula given in paragraph 10 and substituting the values for a four channel set working at 40 words per minute we have

$$\frac{60 \times \text{cycles per second}}{\frac{1}{2}\,S} = \frac{60 \times 40}{10} = 240 \text{ R.P.M.}$$

as the required distributor speed. To find the proper position for the movable weights on the fork to give this distributor speed we refer to the curve given in Section 2 and find opposite 40 W.P.M. or 240 R.P.M. that the B weights give this speed when placed on the end of the tines.

12. Having properly placed the weights in this position, the 110 volt local and the line potential switches in the distributor terminal box are closed. After turning on the switch in the base of the fork the fork is started by pinching the tines together and releasing them. Next the handle of the distributor motor rheostat is pulled forward so that all its resistance is cut out and the distributor starter motor rotated on its pedestal until its

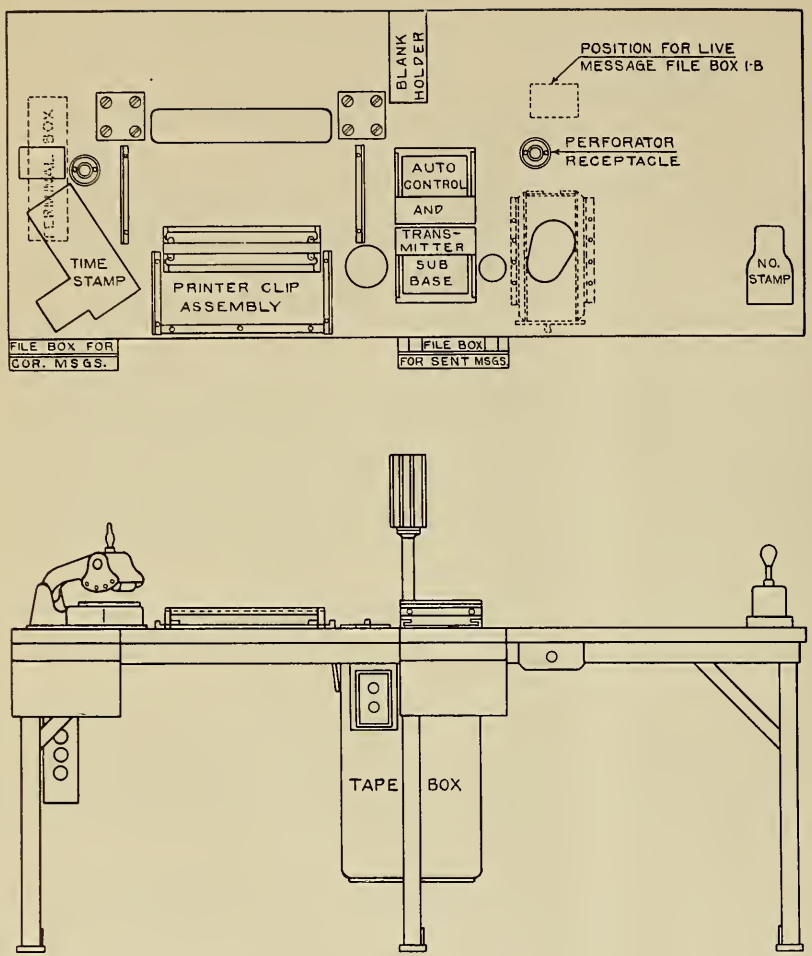



Fig. 6-A

friction wheel engages the distributor flywheel and starts the distributor in rotation. When the distributor has been brought up to about the proper speed the switch in the base is closed and the starter motor disengaged. If the motor has been brought to the proper speed the impulse motor will pick up the load and keep the distributor in rotation. A little practice soon enables one to start the motor with ease.

**13.** Before actually connecting the set to the line it may be advisable to test it on a short; i. e., to send from our transmitting apparatus to our own printers, and thus make certain that the set as a whole functions properly. To do this the distributor face plate

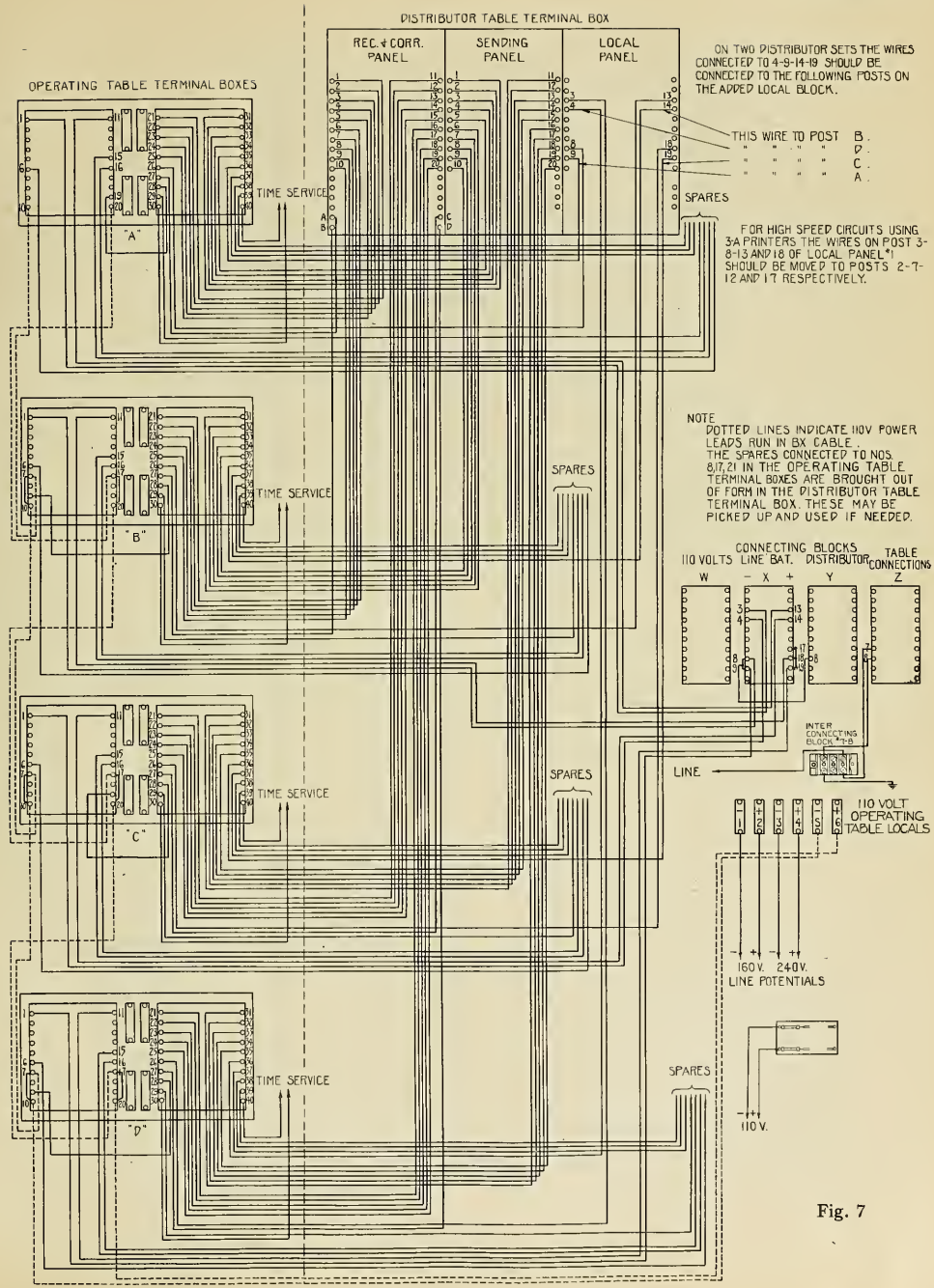

DISTRIBUTOR TABLE TERMINAL BOX
REC. & CORR. PANEL
SENDING PANEL
LOCAL PANEL
OPERATING TABLE TERMINAL BOXES
ON TWO DISTRIBUTOR SETS THE WIRES CONNECTED TO 4-9-14-19 SHOULD BE CONNECTED TO THE FOLLOWING POSTS ON THE ADDED LOCAL BLOCK.
THIS WIRE TO POST B.
" " " " D.
" " " " C.
" " " " A.
SPARES
FOR HIGH SPEED CIRCUITS USING 3-A PRINTERS THE WIRES ON POST 3-8-13 AND 18 OF LOCAL PANEL #1 SHOULD BE MOVED TO POSTS 2-7-12 AND 17 RESPECTIVELY.
TIME SERVICE
"A"
"B"
"C"
"D"
NOTE
DOTTED LINES INDICATE 110V POWER LEADS RUN IN BX CABLE. THE SPARES CONNECTED TO NOS. 8,17,21 IN THE OPERATING TABLE TERMINAL BOXES ARE BROUGHT OUT OF FORM IN THE DISTRIBUTOR TABLE TERMINAL BOX. THESE MAY BE PICKED UP AND USED IF NEEDED.
CONNECTING BLOCKS
110 VOLTS
LINE BAT.
DISTRIBUTOR
TABLE CONNECTIONS
W
X
Y
Z
INTER CONNECTING BLOCK #1-B
LINE
110 VOLT OPERATING TABLE LOCALS
160 V.
240 V.
LINE POTENTIALS
110 V.

Fig. 7

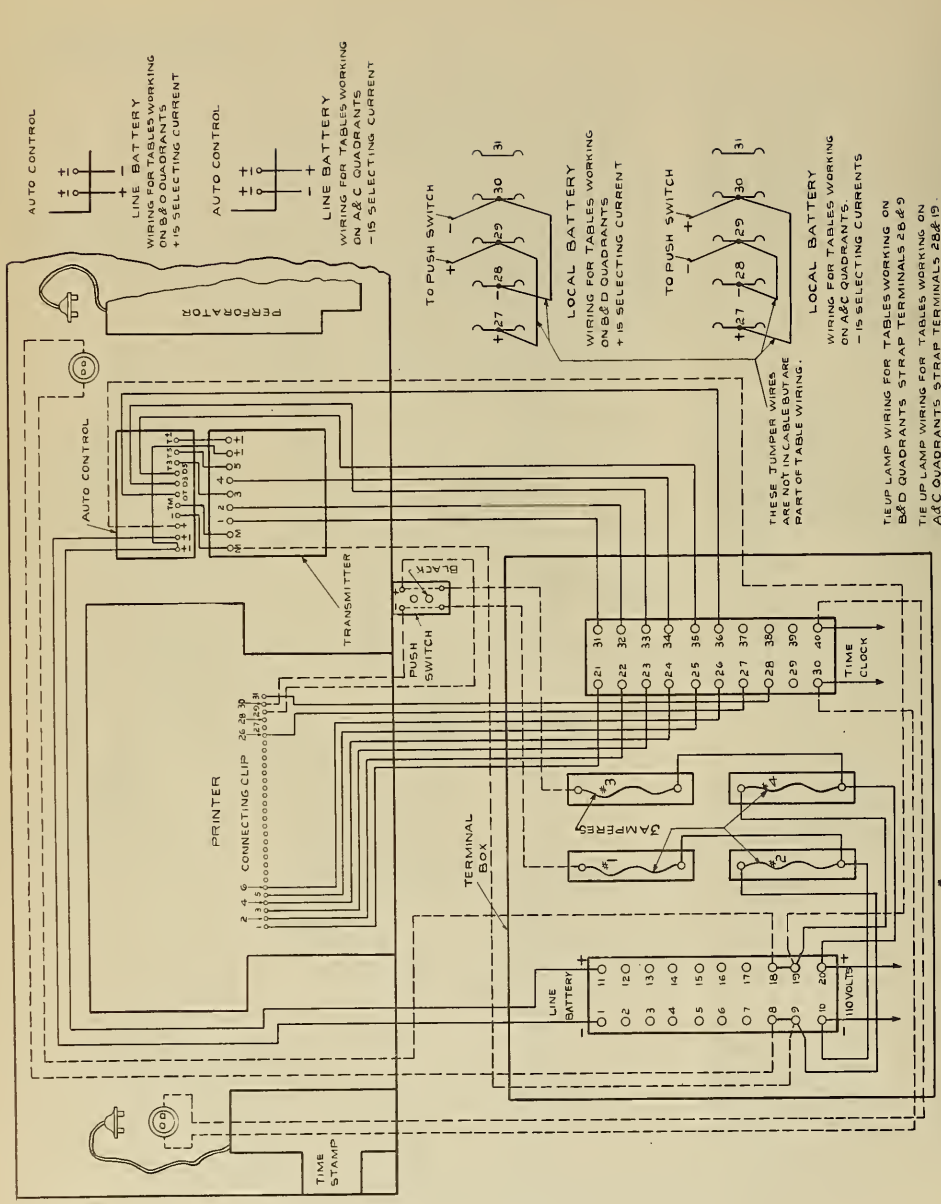

AUTO CONTROL
LINE BATTERY
WIRING FOR TABLES WORKING ON B&D QUADRANTS
+15 SELECTING CURRENT
AUTO CONTROL
LINE BATTERY
WIRING FOR TABLES WORKING ON A&C QUADRANTS
-15 SELECTING CURRENT
PERFORATOR
TO PUSH SWITCH
LOCAL BATTERY
WIRING FOR TABLES WORKING ON B&D QUADRANTS
+15 SELECTING CURRENT
TO PUSH SWITCH
LOCAL BATTERY
WIRING FOR TABLES WORKING ON A&C QUADRANTS.
-15 SELECTING CURRENTS
THESE JUMPER WIRES ARE NOT IN CABLE BUT ARE PART OF TABLE WIRING.
TIE UP LAMP WIRING FOR TABLES WORKING ON B&D QUADRANTS STRAP TERMINALS 28&29
TIE UP LAMP WIRING FOR TABLES WORKING ON A&C QUADRANTS STRAP TERMINALS 28&19
AUTO CONTROL
TRANSMITTER
PUSH SWITCH
BLACK
PRINTER
CONNECTING CLIP
TERMINAL BOX
3 AMPERES
#1
#2
#3
#4
TIME CLOCK
LINE BATTERY
110 VOLTS
TIME STAMP
18 ARMORED LAMP CORD.

Fig. 8

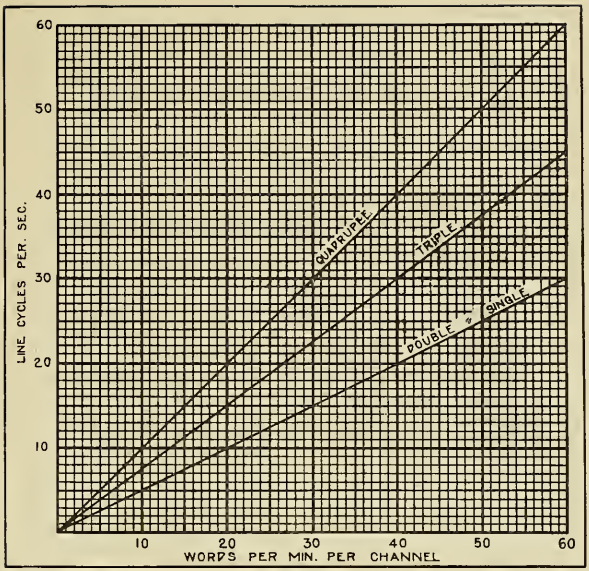



Fig. 9

plugs are inserted so that the small index pin on the outside edge of the connector plugs is opposite hole No. 1 on all three plugs, the plug marked R & C in the plug socket marked Rec. and Corr., the one marked S in the socket marked Send, and the one marked L in the socket marked Local. Then throw the battery switch C on the table top, the cam switch, the switch on the pole-changer key, and the D switch to the left. The balancing condenser ground switch (A switch) and line switch (B switch) are left open; i. e., in their middle positions. There is now only one operation left to perform before the transmitters and printers can be started. This operation is of primary importance, however, and always should be done with care.

**14.** This operation is known as that of taking a range. We should recall here that there are twice as many receiving segments as there are sending segments, and that only every other one is used for operating the printer selecting magnets. These must be so placed with respect to the incoming waves that the best part of each wave is utilized.

**15.** When all the transmitters are shut off (idle), and the pole-changer key switch and cam switch both to the left positive battery is sent from the A channel transmitter on sending segments 1 to 5 inclusive, negative from the B channel on segments 6 to 10 inclusive, positive from C on 11 to 15 inclusive, and negative from D on 16 to 20 inclusive. If the receiving ring is properly placed with respect to the incoming signals the block sent from the A channel will be received on the A channel receiving ring segments (1b to 5b inclusive), the block from the B channel on the corresponding receiving segments, etc. The reversals will therefore always fall on receiving segments 1a, 5a, 10a and 15a, which are not connected electrically with any of the printer selecting mechanism. Under this condition no selections are set up in the printers. If the receiving ring on the distributor is rotated in the clockwise direction a point will finally be reached when the reversal that should take place on 20a falls on segment 1, the one that should fall on 5a comes on 6, and so on, and if the reversals get far enough over on the selecting segments to energize the selecting magnets the printers will begin to print the letter "E." If the receiving ring is rotated in the counter-clockwise direction the reversals, instead of falling

on 20a, 15a, etc., will fall on 20, 15, etc., and the printers will eventually print the letter "T." It is obvious that if we carefully observe just how far the receiving ring can be rotated in each direction before the printers start to print "E" and "T" and then set the ring at a point exactly midway between these two points the selecting segments will be located in the best position on the wave. The outside casting of the receiving ring has a scale mounted on it for convenience in taking a range. This, as has been stated, is the simplest method, but since it is not the most accurate method, others usually are employed. One of these methods will be described in a later paragraph.

16. Having now taken a range, run test tapes in the transmitters and watch the operation on the printers. Test tapes bearing any characters whatever may be used but it is a common practice to punch a line or two of tape with the characters R and Y alternately, because these characters cause the even and the odd selecting magnets to be operated alternately, and then to follow this R Y slip with some sentence containing all the letters of the alphabet as well as figures. If the characters of these tapes are properly printed we may feel satisfied that the set is O. K. and ready to be placed in actual operation.

17. The test is terminated by stopping the transmitters, always remembering to throw the stop and start latch to the stop position before shutting off the switch in the base of the transmitter. Going over to the distributor table the pole-changer key switch is thrown to the right, thus switching the split of the main line relay from the solid sending ring to the pole-changer key so that Morse signals can be sent to the line; also throw the D switch to the right thus disconnecting the receiving ring and substituting in its place a sounder circuit so that Morse signals can be received from the distant terminal. The A switch (balancing condenser ground switch) and the B (line) switch must both be thrown to the left. As their names imply, the A switch connects the ground to the balancing condensers and the B switch connects the set to the telegraph line.

18. The next step in putting the set into actual operation on the line is to call the distant station and in conjunction with him take a duplex balance. This should be very carefully done, for a slight unbalance is extremely detrimental at the high speeds at which multiplex circuits operate. Especially is this true of the static balance. Since a balance against alternating current gives a better balance than one taken against ground, each station will be required to send alternating current to the line during some period of the balancing process. This is accomplished by transferring the sending ring plug (marked S) to the plug socket block marked BALC. This block has positive and negative line battery connected to alternate sockets. When the sending plug is put into it positive and negative line battery is therefore placed upon alternate sending segments and the solid ring is connected by means of the center pin to the line. After the plug has been changed the pole-changer key switch must be thrown to the left to close the circuit to line. The balance shall be taken in accordance with the routine practice of the Traffic Department as described in the latest issue of Traffic Circular Letter 88, using an undulator to check the static balance and the local meter to check the resistance balance.

19. When a proper balance has been obtained the two distributors must be placed in synchronism. If it is assumed that both stations have set their speed and tested the sets on a short as described, the speeds of the two distributors are nearly the same. The station that is to be the correcting station asks the non-correcting station to send correction. The attendant at the non-correcting station then throws the cam switch to the right and closes the pole-changer key switch.

20. Since the circuits controlled by the cam switch are somewhat involved it might be advisable to digress here and study the operation of this switch in order to obtain a clear conception of its function. (See also description in Section 2.) Figure 10 shows the circuits directly controlled by the cam switch. The switch is shown in its normal (operating) position. If the switch lever is thrown to the right the following modifications are made in the circuits shown:

(a) Positive local battery is supplied to all transmitter operating magnets, regardless of the position of the local brushes, through cam contacts 10-9-8-7-6, thus causing the transmitter tongues to be placed in contact with the spacing contacts.

(b) The line battery on the spacing contacts of the B and D transmitters is reversed through the action of cam contacts 1-2-3, thus putting positive battery on all sending segments except No. 20, which is made negative through the action of cam contacts 11-12-13.

(c) The circuit from correcting segments 1a-19a inclusive to the synchronizing unit make relay is broken through the action of cam contacts 4-5. (Note that the path from correcting segment 20a to the make relay is not disturbed.)

**21.** When the distant station throws his cam switch to the right and closes his pole-changer key switch in answer to our request for correction his set will send to the line one short negative and one long positive impulse per revolution. At the correcting station we must now first check our speed to be certain that we are running close enough to the non-correcting station's speed to permit the corrector to take care of the difference, and after the speed has been properly checked, and adjusted if necessary, the correcting impulse must be made to fall on the proper receiving and correcting segments on our distributor.

**22.** To accomplish the first, turn the incoming signals to the printers by throwing the D switch to the left and observe the operation of the printers. Since negative is the selecting battery on the A and C channels, one of the combinations consisting of one marking and four spacing impulses (E, line feed, space, carriage return, and T) will be selected if the correcting pulse falls on the A or C channel receiving segments. If it falls on the B or D selecting segments one of the combinations consisting of one spacing and four marking impulses (V, X, type shift Q, and K) will be selected, because positive is the selecting battery on these channels. If the speed of the two distributors is exactly alike, the same character will be selected and printed as long as the distant station continues to send correction. If the speed of the correcting station's distributor is slow with respect to the non-correcting station's speed, the correcting impulse will gradually fall back on the receiving segments from 20 to 19 to 18, etc., which will result in changing the characters selected on the printers in the order K, Q, typeshift, X, V on the D channel, then T, carriage return, space, line feed, E on the C channel, followed by K, Q, etc., on the B channel, and so on. The number of times each character is selected indicates the difference in speed. If the speed of the correcting station is fast with respect to the non-correcting station, as it should be, the correcting impulse will drift ahead on the segments, resulting in the selecting of the characters in the reverse order of that just given. The proper speed is indicated when each character is repeated from thirty to sixty times before the correcting impulse drifts forward from one segment to another. To illustrate, let us assume that when we return the incoming signals to the printers the D channel printer immediately starts printing VVVVV and then changes to XXXXXX. From thirty to sixty impressions of the letter "X" should be made before the printer begins to operate the typeshift mechanism, and this mechanism should be operated the same number of times before the printer begins to print QQQQQQ. If the speed is found to be either too slow or too fast, the speed of the fork must be adjusted by moving the weights, the sliding weights if only minor changes are needed and the stationary ones if the adjustment required is greater than can be taken care of with the sliding weights.

**23.** The sets must now be placed in synchronism. The switch on the base of the synchronizing unit is thrown to the "on" position. As the correcting impulse drifts as described in the last paragraph the letter "K" is eventually reached on the D channel printer. When this position is reached the corrector begins to operate, because the single reversal from positive to negative in each revolution should take place just before the corrector brushes reach correcting segment 20a. As it drifts onto 20a, the make relay of the synchronizing unit is made to operate, thus energizing the corrector magnet and stepping the brush shaft back with respect to the motor shaft one and one-half degrees. This operation is repeated every time the correcting impulse drifts far enough to reach correcting segment 20a, thus maintaining the phase and speed relationship of the two distributors. If the correction impulse happens to fall on the A or B channel receiving segments immediately after we have determined the speed to be correct, time may be saved in bringing the sets in "step" by operating the button on the synchronizing unit.

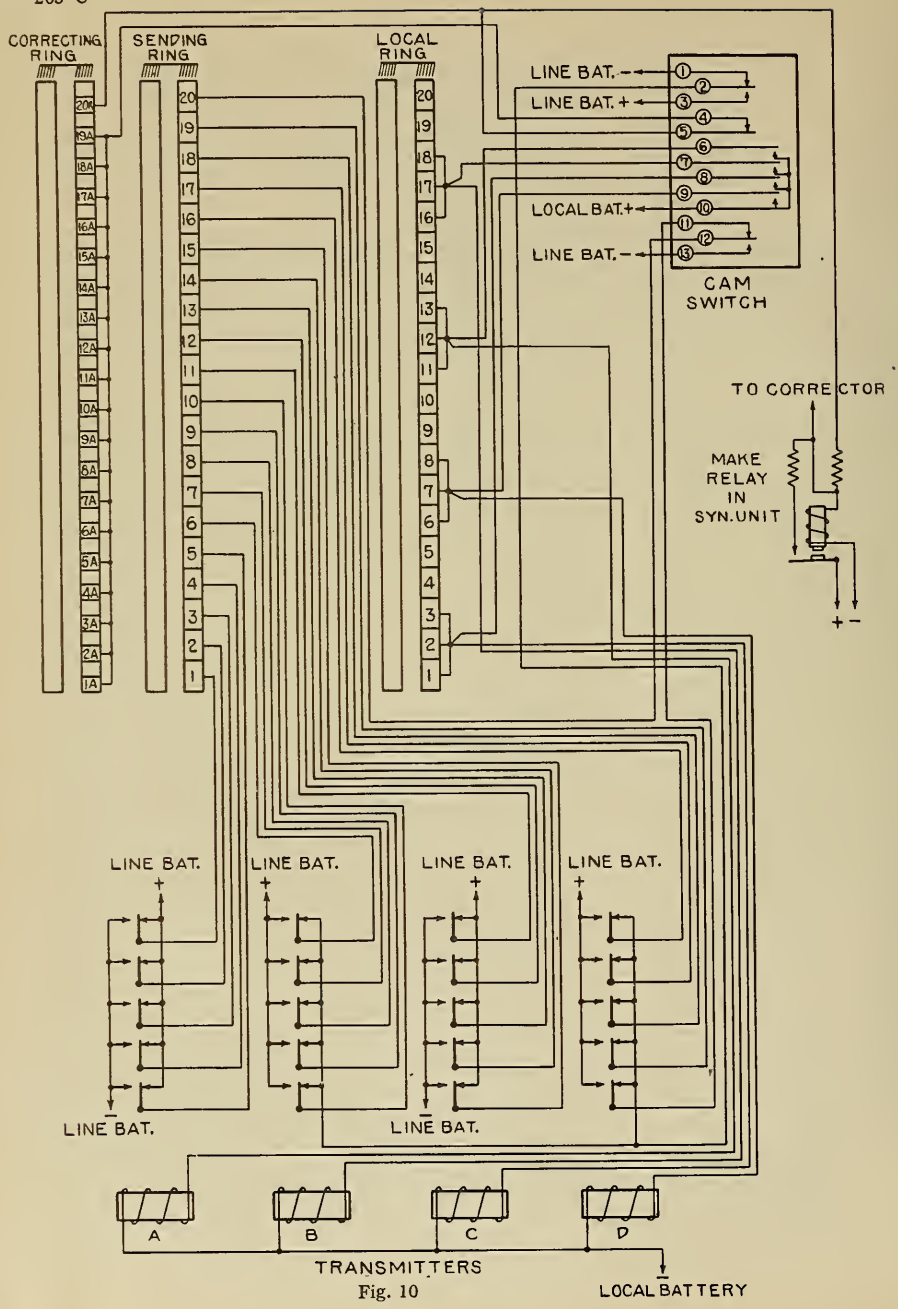

CORRECTING RING
SENDING RING
LOCAL RING
LINE BAT. –
LINE BAT. +
LOCAL BAT. +
LINE BAT. –
CAM SWITCH
TO CORRECTOR
MAKE RELAY IN SYN. UNIT
LINE BAT.
LINE BAT.
LINE BAT.
LINE BAT.
LINE BAT.
LINE BAT.
A
B
C
D
TRANSMITTERS
LOCAL BATTERY

Fig. 10

This operates the corrector and "backs up" the correction impulse with respect to the receiving segments. This backing up is continued until the D printer prints the letter "K," which indicates the proper position. Having reached this position, the cam switch and the pole-changer key switches are thrown to the left. Reversals from our distributor are now sent to the line. The operation of the distant sounder notifies that station that we are "in step," whereupon the distant operator closes his cam switch and turns the signals to the printers by throwing the D switch to the left.

**24.** Both stations now take an idle range, exactly as was done for testing the sets on a short, but unless the line is very short the non-correcting station, due to the reflected line lag, probably will find that he cannot reach the E and T limits on his face plate. This must be compensated for as explained in Section 2. The correcting station is asked to move his sending plug so that the index pin is over hole No. 2. The sets are then placed in step again and if the non-correcting station is still unable to reach both limits he moves his own plug to 2, after which the sets are again synchronized. This process of taking up one segment at each end of the circuit is continued until the non-correcting station can reach both the E and T limits on his face plate. Experience soon teaches one to estimate quite correctly how many segments lag need be taken up for a circuit of a certain length so that in practice the sending plugs are located in positions that are approximately correct when the circuit is placed in synchronism for the first time. After the amount of lag has been determined for a given circuit the plugs need be changed only when the circuit is "patched" or affected by very unusual conditions.

**25.** The next step is to run test tapes between the two stations. The same tapes that were used to test the sets on a short may be used. All channels should be operated both ways simultaneously. While these tests are running a new range should be taken by rotating the face plates as before and noting how far in each direction the receiving ring can be rotated without causing the printers to make errors and finally setting the ring midway between these two points. A range obtained in this way usually differs slightly from the range obtained with the transmitters idle. Other methods of taking a range are also in use but the two described are fundamental and will suffice for this description.

**26.** If the tests are received correctly the sets are ready to use and the Automatic Chief so advises the Traffic Supervisor who is responsible for the placing of operators, etc.

**27.** The operation of starting a circuit—i. e., matching speed, getting in synchronism, taking a range, etc.—is done exactly the same way for any single distributor set. A slight modification of the set itself must, however, be made if we wish to change the number of channels. Let us take first a three channel set, and see how this differs from the four channel set with which we are now familiar.

**28.** Obviously, one operating table and its associated units are dispensed with. Since the fifth impulse of the D channel is tied up with the synchronizing mechanism, this channel must not be disturbed. The A table is therefore the most convenient one to remove. No change is made in the other tables. The three channel face plate, described in Section 2, must be substituted for the four channel face plate. Since this face plate has only fifteen sending segments, five of the twenty pins in the plug are not used. If it became necessary to rotate the plug to take up lag, one or more of these unused pins would connect with live transmitter connections, and some of the live pins would connect with the unused pin sockets 1 to 5 inclusive (formerly used for the A channel). To overcome this difficulty the first five sockets are paralleled with 5 to 10 inclusive, by placing five straps on the sending plug panel as shown in Figure 11. This figure also shows which pins and sockets are used, and the complete connections between the segments on the face plate and the terminals on all three panels.

**29.** These are all the changes needed for the actual operation of the set, but in order to be able to send alternating current for balancing purposes another addition must be made. When we wished to send alternating current with the four channel set it was necessary only to move the sending plug to the balancing block and close the pole-changer key switch. Alternating current was produced by virtue of the fact that every other one of the twenty segments was connected to opposite battery when the plug was placed

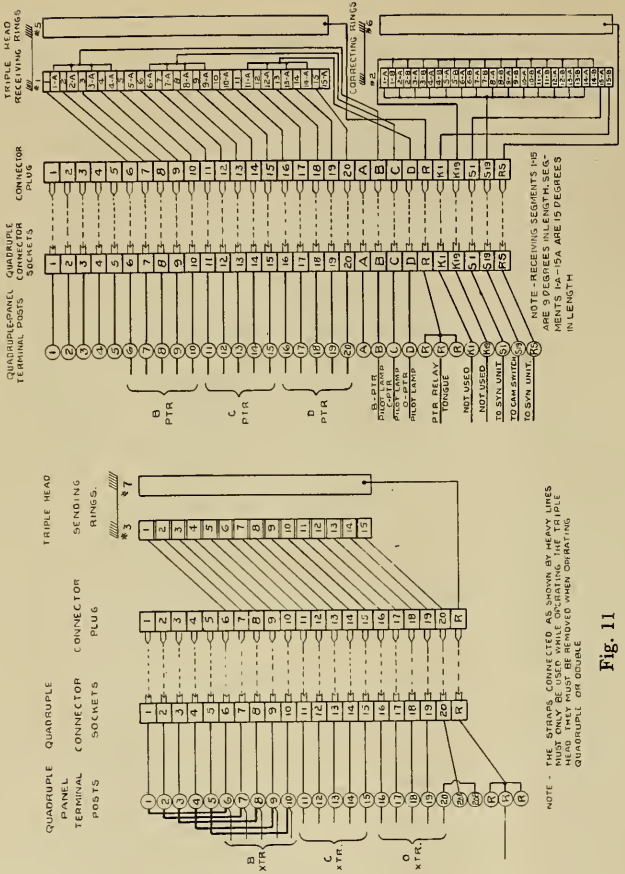

TRIPLE HEAD SENDING RINGS #1 #5
CORRECTING RINGS #6 #2
QUADRUPLE-PANEL TERMINAL POSTS
QUADRUPLE CONNECTOR SOCKETS
CONNECTOR PLUG
B PTR
C PTR
D PTR
B PTR POSITIVE C PTR POSITIVE D PTR POSITIVE PILOT LAMP
PTR RELAY TONGUE
NOT USED
NOT USED
TO SYN UNIT
TO CAM SWITCH
TO SYN UNIT
NOTE - RECEIVING SEGMENTS #8 ARE 9 DEGREES IN LENGTH. SEGMENTS #A-15A ARE 15 DEGREES IN LENGTH
QUADRUPLE PANEL TERMINAL POSTS
QUADRUPLE CONNECTOR SOCKETS
CONNECTOR PLUG
TRIPLE HEAD SENDING RINGS.
B XTR.
C XTR.
D XTR.
NOTE - THE STRAPS CONNECTED AS SHOWN BY HEAVY LINES MUST ONLY BE USED WHILE OPERATING THE TRIPLE HEAD. THEY MUST BE REMOVED WHEN OPERATING QUADRUPLE OR DOUBLE
D PTR
D XTR
B PTR
B XTR.
C PTR
C XTR.
110V +
TRIPLE HEAD LOCAL RINGS

Fig. 11

in the balancing block. The triple head has an odd number of segments, hence cannot be divided into equal number of plus and minus battery connections, so that when the sending plug is placed in the balancing block, so-called flat wheel alternating current is produced. This is not convenient for balancing. A separate unit for producing alternating current for balancing purposes is therefore furnished with triple sets. It is a simple commutator device mounted on the distributor flywheel guard and driven by the flywheel through a friction wheel. The complete unit as mounted is shown in Figure 12 and its wiring, together with its associated F switch, is shown by dotted lines in Figure 5. When the F switch is thrown to the right the battery leads to the C switch are opened and positive and negative line battery connected direct to alternate segments of the balancing distributor. A catch normally holds the friction wheel away from the flywheel; as soon as this catch is released the commutator is made to rotate, thus sending alternating current to the line. With this extra alternating current unit added and the heads changed and sending panel strapped as shown we have completely converted our four channel Multiplex set to a three channel set.

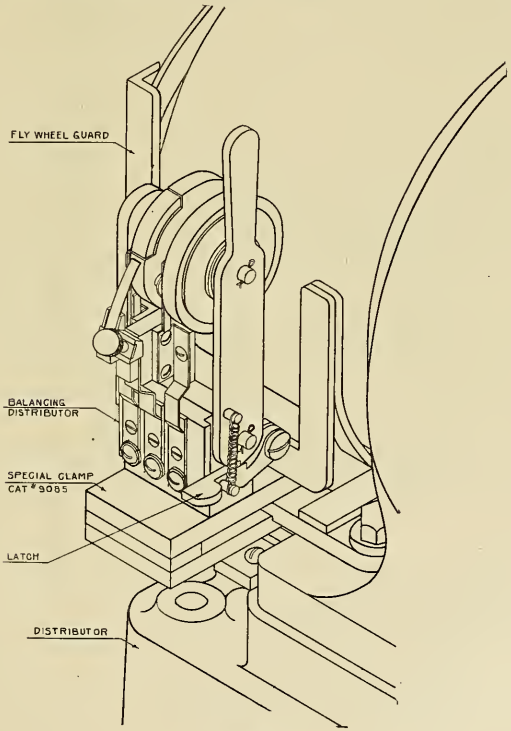



Fig. 12

**30.** If only two channels are required we remove the B channel table from the three channel set, remove also the special balancing distributor and its associated F switch, change the face plate for a two channel face plate, and rearrange our strapping to completely convert the set to a two channel unit. On the three channel unit connections

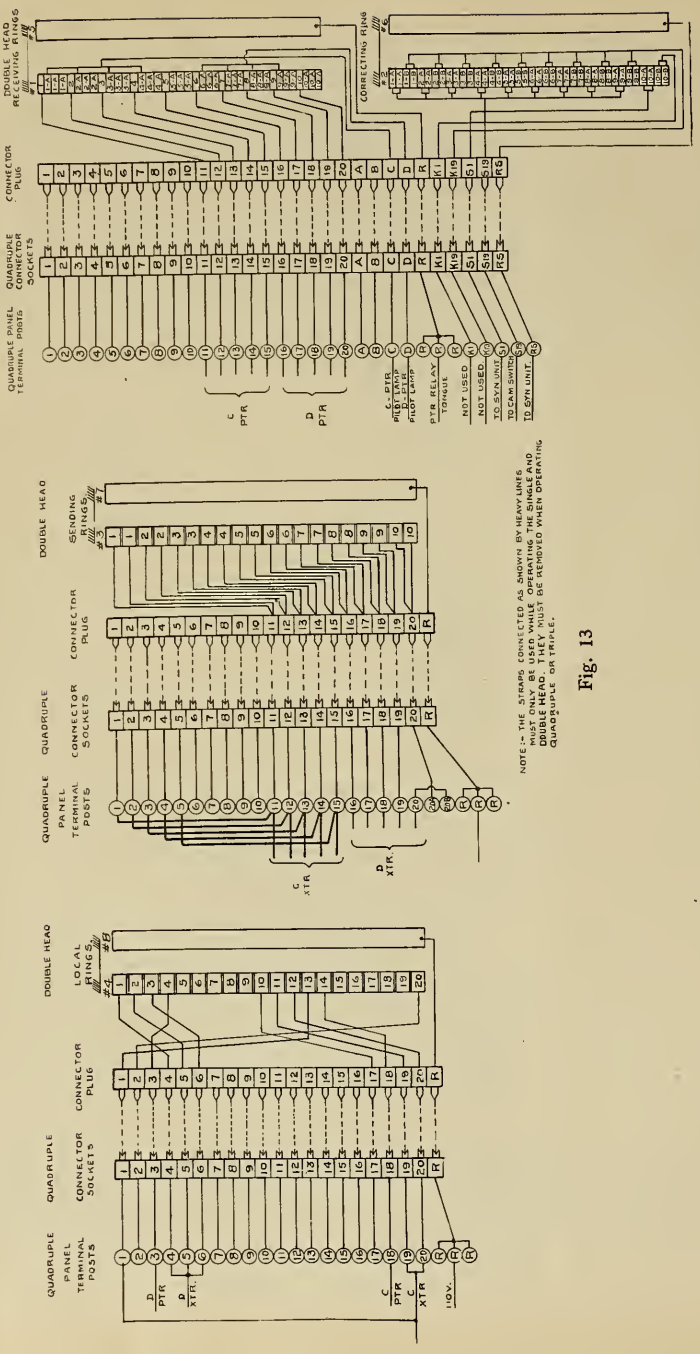

DOUBLE HEAD
RECEIVING RINGS
#1
#2
CORRECTING RING
#3
CONNECTOR PLUG
QUADRUPLE CONNECTOR SOCKETS
QUADRUPLE PANEL TERMINAL POSTS
C PTR
D PTR
C PTR PILOT LAMP
D PTR PILOT LAMP
PTR RELAY
TONGUE
NOT USED
NOT USED
TO SYN UNIT
TO CAM SWITCH
TO SYN UNIT
DOUBLE HEAD
SENDING RINGS
#1
#2
#3
QUADRUPLE CONNECTOR PLUG
QUADRUPLE CONNECTOR SOCKETS
QUADRUPLE PANEL TERMINAL POSTS
C XTR
D XTR
NOTE:- THE STRAPS CONNECTED AS SHOWN BY HEAVY LINES MUST ONLY BE USED WHILE OPERATING WITH SINGLE HEAD AND DOUBLE ENDED TAPE. THEY MUST BE REMOVED WHEN OPERATING QUADRUPLE OR TRIPLE.
DOUBLE HEAD
LOCAL RINGS
#1
#2
#3
QUADRUPLE CONNECTOR PLUG
QUADRUPLE CONNECTOR SOCKETS
QUADRUPLE PANEL TERMINAL POSTS
D PTR
D XTR
C PTR
C XTR
GOV.

Fig. 13

1 to 5 were strapped to 6 to 10 inclusive because on the three channel head only 15 segments are used. In the two channel head the segments are used in pairs so that electrically, there are only ten segments. To serve the same purpose as the straps used with the three channel head the straps must now be placed from 1 to 11, 2 to 12, etc. Usually only five straps are used, as this is sufficient to take up the maximum amount of lag encountered. The strapping, together with the wiring of the head and the relative position of the different segments with respect to the panels, is shown in Figure 13.

**31.** The line frequency of two channel sets is sufficiently low to permit the operation of almost any circuit at a speed approaching the maximum speed of the sets. To produce a single channel set by reducing the number of segments and consequently the line speed would therefore not be of a great advantage, and would involve the construction of special equipment for maintaining synchronism when the sets are idle, as well as special locking circuits for the printing of one selection simultaneously with the setting up of the following selection. Where single channel sets are required the C channel of a double is removed and the connections on the sending plug panel usually occupied by the C transmitter are permanently wired to line battery to provide correcting impulses when the set is idle. No other change is made. This wiring is shown in Figure 12. Note that the battery from 8 and 9 on the X block, which is normally negative, comes through the cam switch so that when this switch is thrown to the right connections 11 to 15 inclusive as well as the first four tongues of the D transmitter are all connected to positive (spacing) battery. All connections for the single channel wiring and the position of the segments with respect to them are also shown on Figure 14.

**32.** All of the sets so far described require one distributor at each terminal. These sets work very well on comparatively short lines where the amount of line lag is not equal to more than three or four segments. As the circuits increase in length it becomes more and more difficult to properly compensate for the reflected line lag. When it becomes necessary to take up more than three segments lag at each terminal the time of operation of the transmitter magnets comes so close to the time the sending brush passes over the corresponding transmitter segments that the transmitter tongues do not have a sufficient time to settle down to a firm contact before they are actually connected to the line. This may be compensated for by a rearrangement of the local operating segments, but the most satisfactory solution for the whole problem of lag compensation is to eliminate the need for any compensation whatever. This can be done by completely separating the sending and receiving functions. It involves the addition of a second distributor and auxiliary apparatus to our distributor table equipment, thus changing our set from a single distributor to a two distributor set.

**33.** After this change is made the left hand distributor becomes normally the transmitting distributor. Its sending plug is inserted in the regular sending plug socket of the connector panel in the distributor table terminal box. Its local plug is inserted in a new local block. The receiving and correcting brushes are omitted from the brush holder on this distributor.

**34.** The right hand distributor becomes normally the receiving distributor. Its receiving plug and local plug are inserted in the regular receiving and local sockets in the connector panels. The sending brushes are omitted from the brush holder.

**35.** The unused connector plugs from both distributors shall be covered with multiple plug protectors to prevent injury to the plugs and keep them from short-circuiting other apparatus.

**36.** With two distributor operation both terminals become correcting stations, the receiving distributor, of course, being also the correcting distributor. Each distributor is driven from an individual fork so that it becomes possible to operate the sending distributor at the home station and the receiving distributor at the distant station at one speed, while the sending distributor at the distant station and the receiving distributor at the home station are working at another speed. Since the sending and receiving functions are not performed on the same distributors, synchronism is established on the receiving distributors without reference to the outgoing signals on the sending distributors.

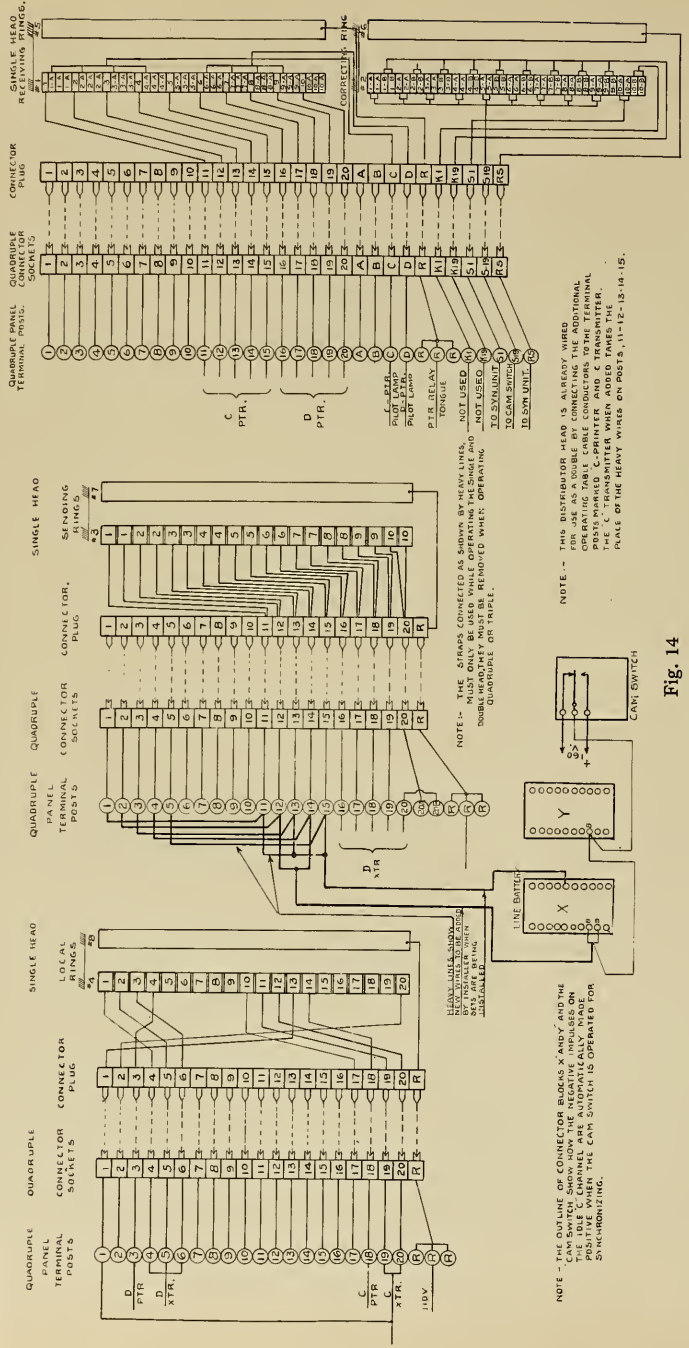

QUADRUPLE PANEL TERMINAL POSTS
QUADRUPLE CONNECTOR SOCKETS
CONNECTOR PLUG
SINGLE HEAD RECEIVING RINGS
CORRECTING RING
C PTR.
D PTR.
PTR. RELAY TONGUE
NOT USED
TO SYN UNIT
TO CAM SWITCH
TO SYN UNIT
SINGLE HEAD SENDING RINGS
D PTR
D XTR.
C PTR
C XTR.
JUV
LOCAL RINGS
LINE BATTERY
CAM SWITCH
NOTE - THE STRAPS CONNECTED AS SHOWN BY HEAVY LINES, MUST ONLY BE USED WHILE OPERATING THE SINGLE AND DOUBLE HEAD, THEY MUST BE REMOVED WHEN OPERATING QUADRUPLE OR TAPE.
NOTE - THIS DISTRIBUTOR HEAD IS ALREADY WIRED FOR USE AS SINGLE HEAD, THE ADDITIONAL OPERATING TABLE CABLE CONDUCTORS TERMINAL POSTS MARKED C-PRINTER AND C TRANSMITTER. THE 'C' TRANSMITTER WHEN ADDED TAKES THE PLACE OF THE HEAVY WIRES ON POSTS, 11-12-13-14-15.
NOTE - THE OUTLINE OF CONNECTOR BLOCKS 'X AND Y' AND THE CAM SWITCH SHOW HOW THE NEGATIVE IMPULSES ON THE IDLE 'C' CHANNEL ARE AUTOMATICALLY MADE POSITIVE WHEN THE CAM SWITCH IS OPERATED FOR SYNCHRONIZING.

Fig. 14

hence the position of the sending plug need never be changed. This plug can therefore be left in its normal position with the index pin opposite socket No. 1 at all times.

**37.** In order to make it possible to back up the sending distributor by operating the button on the synchronizing unit if that should be asked for by the distant station, and also make it possible to use the left hand distributor as the receiving distributor if that should become convenient, a three point switch R is added to the set. This switch is inserted in the circuit from posts 4 and 5 of the synchronizing unit to the distributor corrector. When the switch is to the left (its normal position) the right hand distributor corrector is connected to the synchronizing unit; when to the right the left hand distributor corrector is connected to the synchronizing unit. When the left hand distributor is used as the receiving distributor its receiving and local plugs must, of course, be used, together with the sending and local plugs of the right hand distributor.

**38.** Inasmuch as the cam switch on the regular single distributor set takes care of both the sending and receiving functions simultaneously for purposes of synchronizing a change must be made in this switch in order to separate the two functions. Contacts four and five on the cam switch take care of the receiving function. The wires connected to these contacts are therefore disconnected and an added switch S is placed on the table to perform the function formerly performed by contacts 4 and 5 of the cam switch. When this switch is opened all corrector segments except 20a are disconnected from the synchronizing unit.

**39.** Figure 15 shows the distributor table and Figure 16 the distributor table terminal box layout for two distributor operation. Figure 17 is a complete wiring diagram of the distributor table equipped for two distributor operation.

**40.** Since sets are frequently changed in the field from single to two distributor sets detailed directions for making the change are given in the following paragraphs. Figure 18 shows the wiring of the balancing block 2A which is used as the added local block, Figure 19 shows the location of the added distributor, the added fork meter, the R and S switches, and the new cut-out to be made in the distributor table top. In order to provide room for the two distributors it may be necessary to move the left hand distributor closer to the edge of the table. The added fork shall be located on the right hand side of the sliding fork shelf. Figure 20 shows the location of the added fuses and resistances in the distributor table terminal box. Figure 22 shows the changed and added wiring.

**41.** The following wiring changes must be made:

a. Move present alternating current balancing block and its three wires to the new position just below its present location, as shown in Figure 22.

b. Remove the 15-A connecting block "V" from the terminal box and tape spare cable conductors back on the cable.

c. Remove the three wires connected to posts 4, 5 and 6 of the local connector panel and connect all of them to post D on the added local block. Each wire will have to be spliced and cut out of the cable form going to the local connector block and run down below the balancing block and up on the right hand side of this block.

d. Remove the three wires connected to posts 14, 15 and 16 of the local connector panel and connect all of them to post B on the added local block. These wires also will have to be spliced and run into the same form as those mentioned in paragraph c.

e. Remove the three wires connected to posts 19, 20 and 1 of the local connector panel and connect all of them to post C on the added local block. These wires also will have to be spliced and run into the same form as wires mentioned in paragraphs c and d.

f. Remove the three wires connected to posts 9, 10 and 11 of the local connector panel and connect all of them to post A on the added local block. These wires also will have to be spliced and run into the same form as wires mentioned in paragraphs c, d and e.

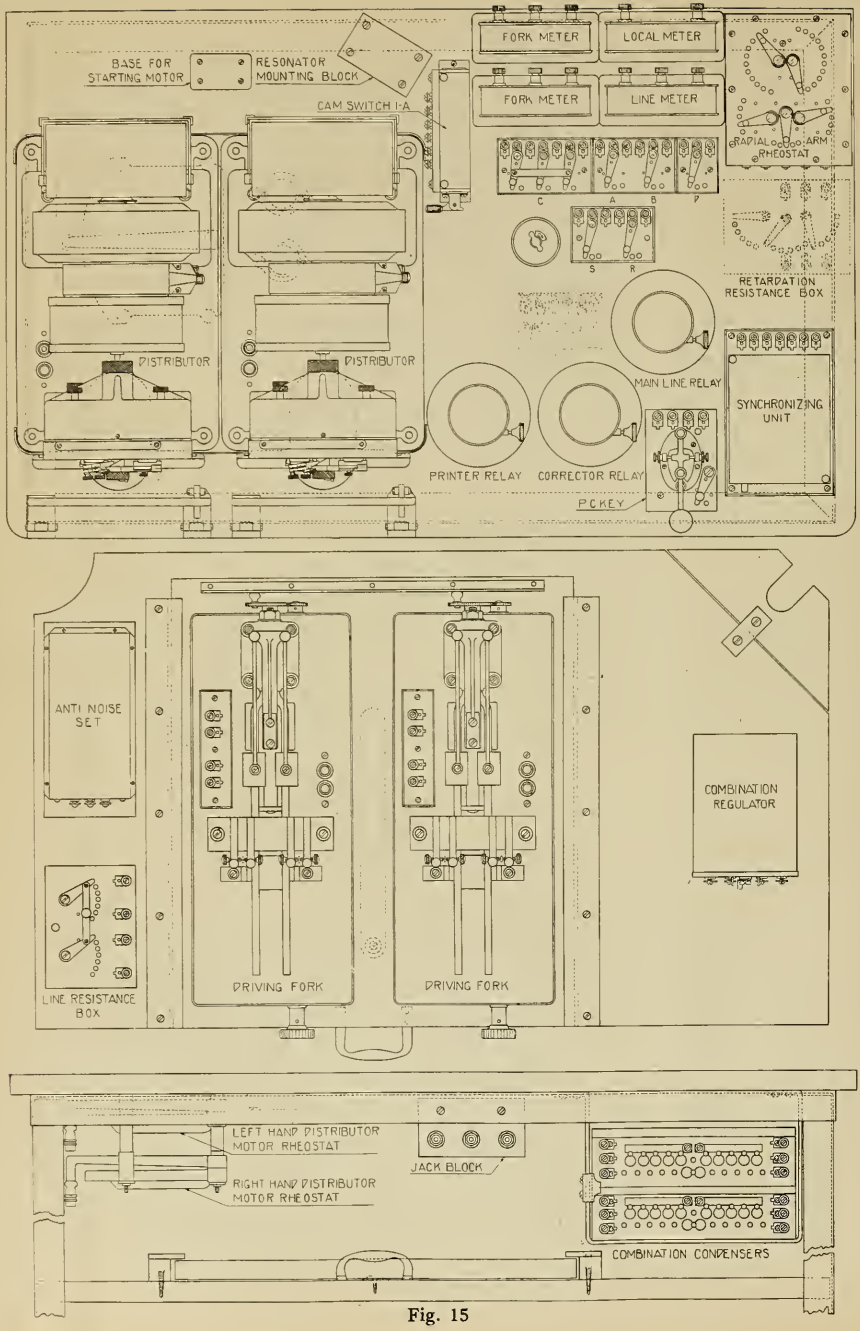
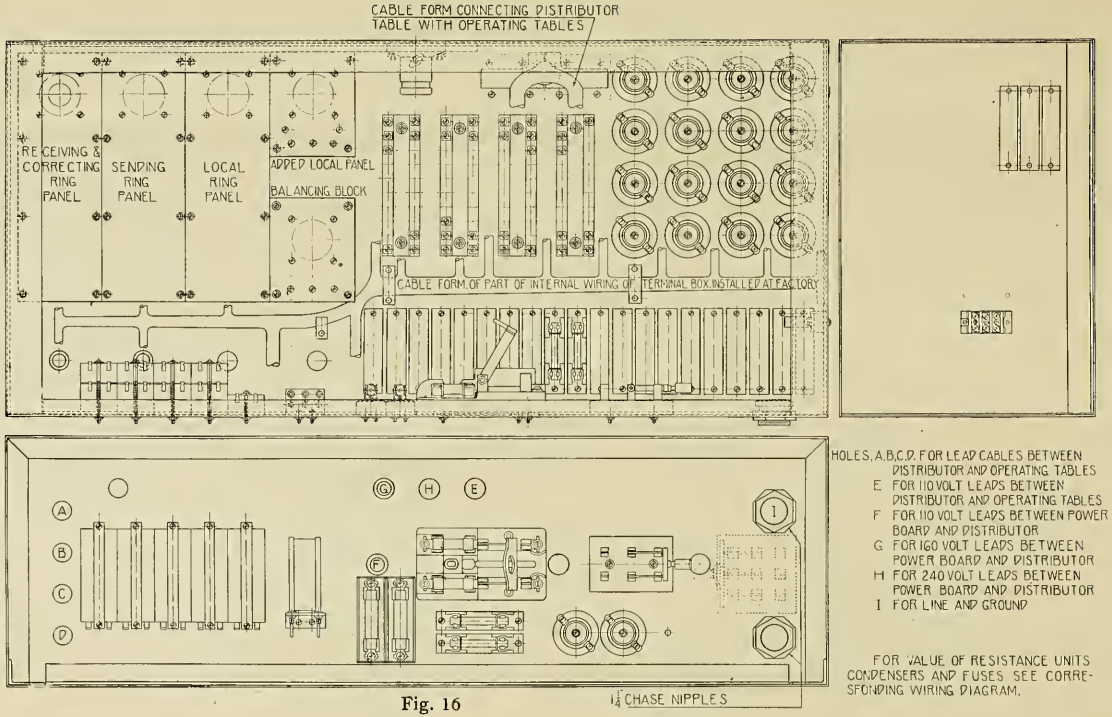

BASE FOR STARTING MOTOR
RESONATOR MOUNTING BLOCK
CAM SWITCH I-A
FORK METER
LOCAL METER
FORK METER
LINE METER
RADIAL ARM RHEOSTAT
C
A
B
D
S
R
RETARDATION RESISTANCE BOX
DISTRIBUTOR
DISTRIBUTOR
MAIN LINE RELAY
SYNCHRONIZING UNIT
PRINTER RELAY
CORRECTOR RELAY
P.C.KEY
ANTI NOISE SET
COMBINATION REGULATOR
LINE RESISTANCE BOX
DRIVING FORK
DRIVING FORK
LEFT HAND DISTRIBUTOR MOTOR RHEOSTAT
JACK BLOCK
RIGHT HAND DISTRIBUTOR MOTOR RHEOSTAT
COMBINATION CONDENSERS

Fig. 15




HOLES, A, B, C, D. FOR LEAD CABLES BETWEEN DISTRIBUTOR AND OPERATING TABLES
E. FOR 110 VOLT LEADS BETWEEN DISTRIBUTOR AND OPERATING TABLES
F. FOR 110 VOLT LEADS BETWEEN POWER BOARD AND DISTRIBUTOR
G. FOR 160 VOLT LEADS BETWEEN POWER BOARD AND DISTRIBUTOR
H. FOR 240 VOLT LEADS BETWEEN POWER BOARD AND DISTRIBUTOR
I. FOR LINE AND GROUND

FOR VALUE OF RESISTANCE UNITS CONDENSERS AND FUSES SEE CORRESPONDING WIRING DIAGRAM.

Fig. 16

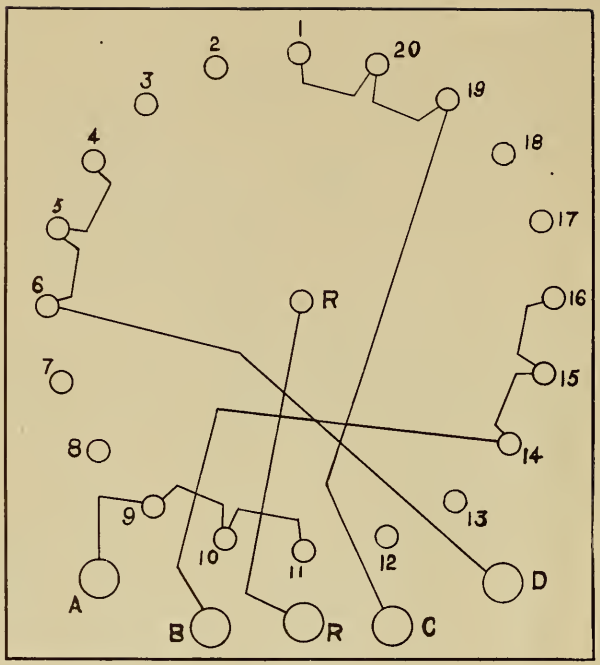



Fig. 18

g. The three wires referred to in each of the above paragraphs are the wires leading to the transmitter condenser, the wire leading to the Z block and the wire leading to the transmitter connection in the operating table terminal box.

h. Remove wire now on post 4 of the cam switch, splice and connect it to post 1 of the S switch.

i. Remove wire on post 5 of the cam switch 1-A and connect it to post 2 of the S switch.

j. Remove wire from posts 4 and 5 of the synchronizing unit, splice and connect it to post 6 of the switch R.

k. Run new wires shown on Figure 22 as per the following list:

From post marked R on added local block (Balc. Block 2-A) to 18 added lamp.

From 18 added lamp to 25 added fuse.

From posts 4 and 5 of synchronizing unit to post 5 of R switch.

From post 4 of switch R to post 2 on right hand distributor.

From post 3 on right hand distributor to post 3 on left hand distributor.

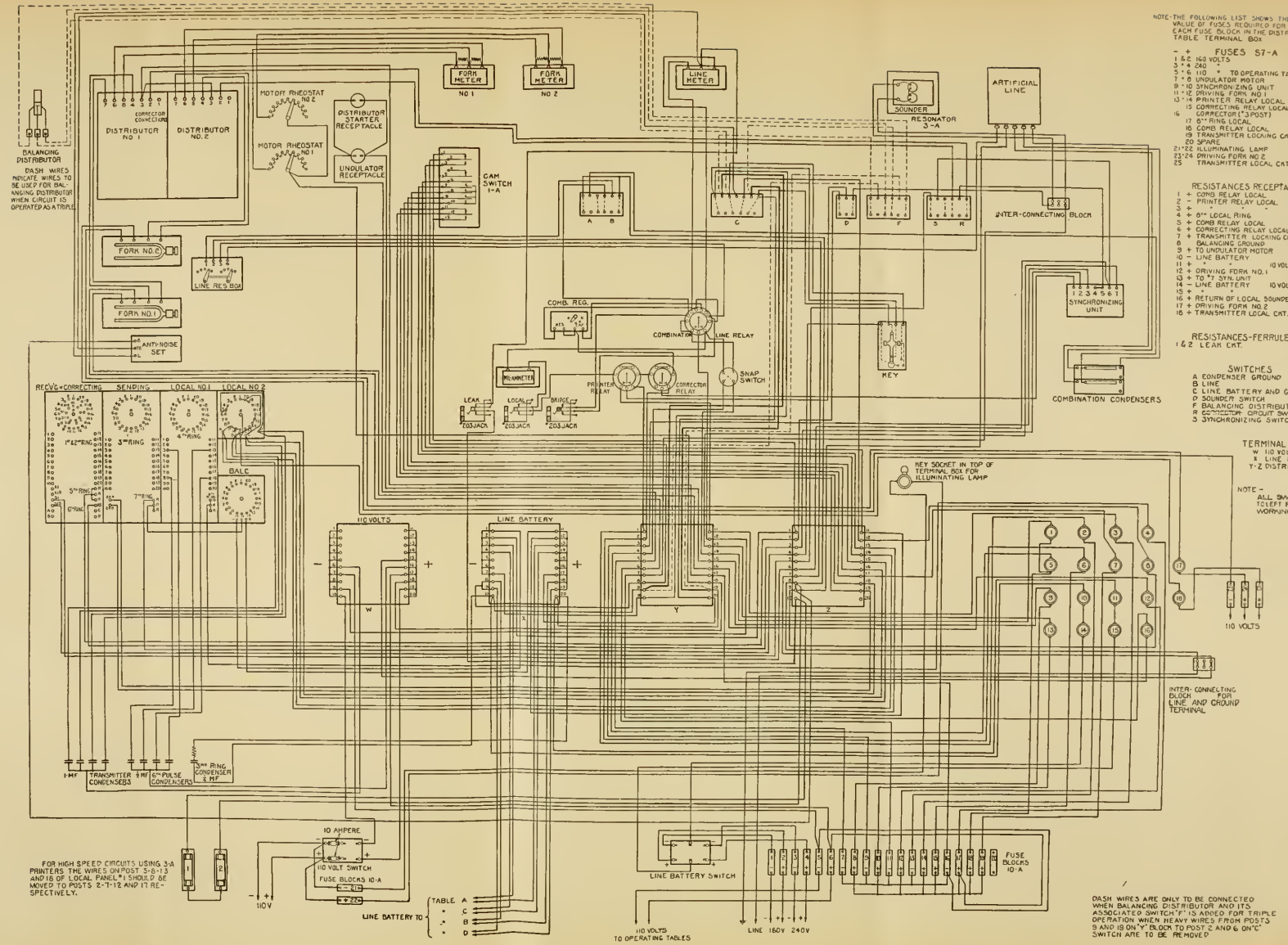

BALANCING DISTRIBUTOR
DASH WIRES INDICATE WIRES TO BE USED FOR BALANCING DISTRIBUTOR WHEN CIRCUIT IS OPERATED AS A TRIPLE
DISTRIBUTOR NO. 1
DISTRIBUTOR NO. 2
CORRECTOR CONNECTORS
MOTOR RHEOSTAT NO 2
MOTOR RHEOSTAT NO 1
DISTRIBUTOR STARTER RECEPTACLE
LINGULATOR RECEPTACLE
FORK METER NO 1
FORK METER NO 2
LINE METER
SOUNDER
RESONATOR 3-A
ARTIFICIAL LINE
CAM SWITCH 1-A
A B
C
D
F
S R
INTER-CONNECTING BLOCK
FORK NO 2
LINE RES BOX
FORK NO 1
ANTI-NOISE SET
COMB. REG.
COMBINATOR
LINE RELAY
PRINTER RELAY
CORRECTOR RELAY
SNAP SWITCH
MILLIAMMETER
LEAK
LOCAL
BRIDGE
KEY
SYNCHRONIZING UNIT
COMBINATION CONDENSERS
RECVG-CORRECTING
SENDING
LOCAL NO 1
LOCAL NO 2
1ST & 2ND RING
3RD RING
4TH RING
5TH RING
6TH RING
7TH RING
BALC
110 VOLTS
LINE BATTERY
W
X
Y
Z
KEY SOCKET IN TOP OF TERMINAL BOX FOR ILLUMINATING LAMP
INTER-CONNECTING BLOCK FOR LINE AND GROUND TERMINAL
1 MF
TRANSMITTER CONDENSERS 1 MF
6TH PULSE CONDENSERS
3RD RING CONDENSER 2 MF
10 AMPERE
110 VOLT SWITCH
FUSE BLOCKS 10-A
110V
LINE BATTERY TO
TABLE A C B D
LINE BATTERY SWITCH
110 VOLTS TO OPERATING TABLES
LINE 160V 240V
FUSE BLOCKS 10-A
FOR HIGH SPEED CIRCUITS USING 3-A PRINTERS THE WIRES ON POST 5-8-13 AND 18 OF LOCAL PANEL "1" SHOULD BE MOVED TO POSTS 2-7-12 AND 17 RESPECTIVELY.
DASH WIRES ARE ONLY TO BE CONNECTED WHEN BALANCING DISTRIBUTOR AND ITS ASSOCIATED SWITCH "F" IS ADDED FOR TRIPLE OPERATION WHEN HEAVY WIRES FROM POSTS 9 AND 18 ON "Y" BLOCK TO POST 2 AND 6 ON "C" SWITCH ARE TO BE REMOVED
NOTE-THE FOLLOWING LIST SHOWS THE VALUE OF FUSES REQUIRED FOR EACH FUSE BLOCK IN THE DISTRIBUTOR TABLE TERMINAL BOX
FUSES 57-A
1 & 2 160 VOLTS 4 AMPERE
3 + 4 240 " 4 "
5 + 6 110 " TO OPERATING TABLES 10 AMP.
7 + 8 UNDULATOR MOTOR 3 AMPERE
9 + 10 SYNCHRONIZING UNIT 1 "
11 + 12 DRIVING FORK NO 1 3 "
13 + 14 PRINTER RELAY LOCAL 1 "
15 CORRECTING RELAY LOCAL 1 "
16 CORRECTOR ("3 POST) 1 "
17 6TH RING LOCAL 1 "
18 COMB RELAY LOCAL 4 "
19 TRANSMITTER LOCKING CKT 1 "
20 SPARE
21 + 22 ILLUMINATING LAMP 1 "
23 + 24 DRIVING FORK NO 2 3 "
25 TRANSMITTER LOCAL CKT 1 "
RESISTANCES RECEPTACLE TYPE
1 + COMB RELAY LOCAL 1000 OHM
2 - PRINTER RELAY LOCAL 250 "
3 " " " 250 "
4 + 6TH LOCAL RING 150 "
5 + COMB RELAY LOCAL 1000 "
6 + CORRECTING RELAY LOCAL 100 "
7 + TRANSMITTER LOCKING CKT 150 "
8 BALANCING GROUND 400 "
9 + TO UNDULATOR MOTOR 10 "
10 - LINE BATTERY 365 "
11 + " 10 VOLT 5 W TUNGSTEN
12 + DRIVING FORK NO. 1 180 OHM
13 + TO "2" SYN. UNIT 50 "
14 - LINE BATTERY 10 VOLT 5 W TUNGSTEN
15 + " " 365 OHM
16 + RETURN OF LOCAL SOUNDER 1000 "
17 + DRIVING FORK NO 2 150 "
18 + TRANSMITTER LOCAL CKT. 150 "
RESISTANCES-FERRULE-TYPE 53-A
1 & 2 LEAK CKT. 10000 OHM
SWITCHES
A CONDENSER GROUND
B LINE
C LINE BATTERY AND GROUND
D SOUNDER SWITCH
F BALANCING DISTRIBUTOR
R CORRECTOR CIRCUIT SWITCH
S SYNCHRONIZING SWITCH
TERMINAL BLOCKS
W 110 VOLTS
X LINE BATTERY
Y-Z DISTRIBUTION
NOTE - ALL SWITCHES TO LEFT FOR NORMAL WORKING
110 VOLTS

Fig. 17

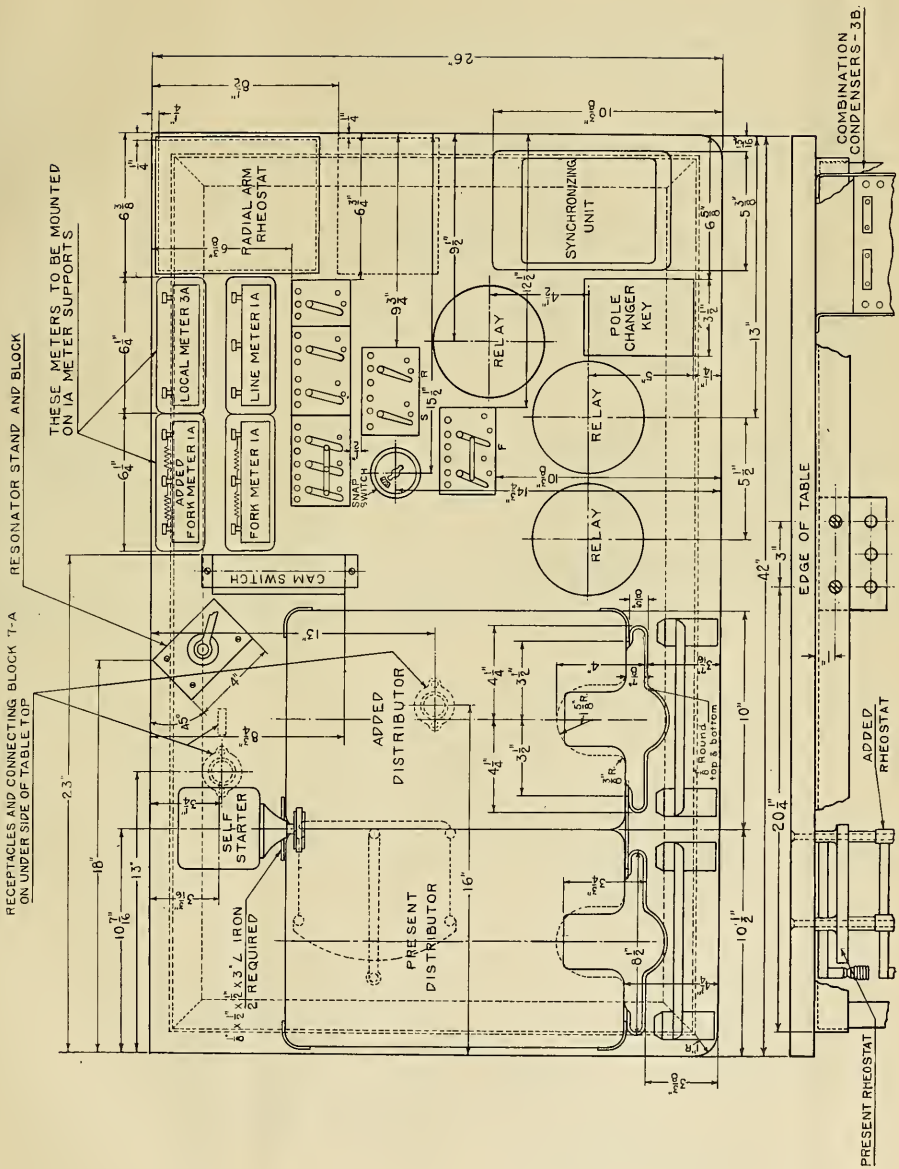

RECEPTACLES AND CONNECTING BLOCK 7-A ON UNDER SIDE OF TABLE TOP
RESONATOR STAND AND BLOCK
THESE METERS TO BE MOUNTED ON IA METER SUPPORTS
ADDED FORK METER IA
LOCAL METER 3A
FORK METER IA
LINE METER IA
RADIAL ARM RHEOSTAT
SYNCHRONIZING UNIT
POLE CHANGER KEY
RELAY
RELAY
RELAY
SNAP SWITCH
CAM SWITCH
ADDED DISTRIBUTOR
PRESENT DISTRIBUTOR
SELF STARTER
6" x 1/2" x 3" IRON REQUIRED
EDGE OF TABLE
COMBINATION CONDENSERS 3B
ADDED RHEOSTAT
PRESENT RHEOSTAT
26"
23"
18"
16"
13"
42"
20 1/4"
10 1/2"

Fig. 19

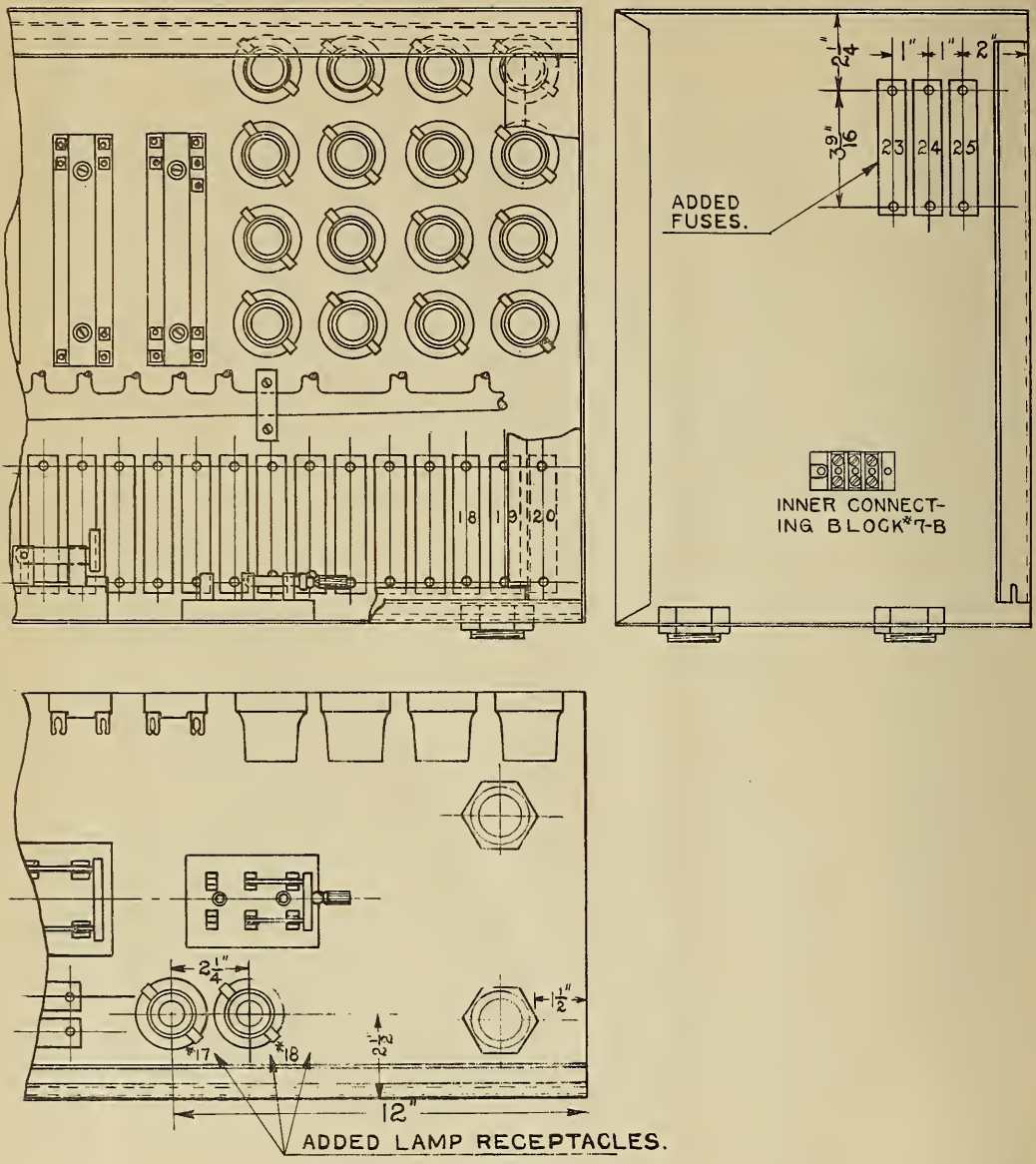

18
19
20
2¼"
1"
1"
2"
39/16"
23
24
25
ADDED FUSES.
INNER CONNECTING BLOCK *7-B
2¼"
½"
2½"
*17
*18
12"
ADDED LAMP RECEPTACLES.

Fig. 20

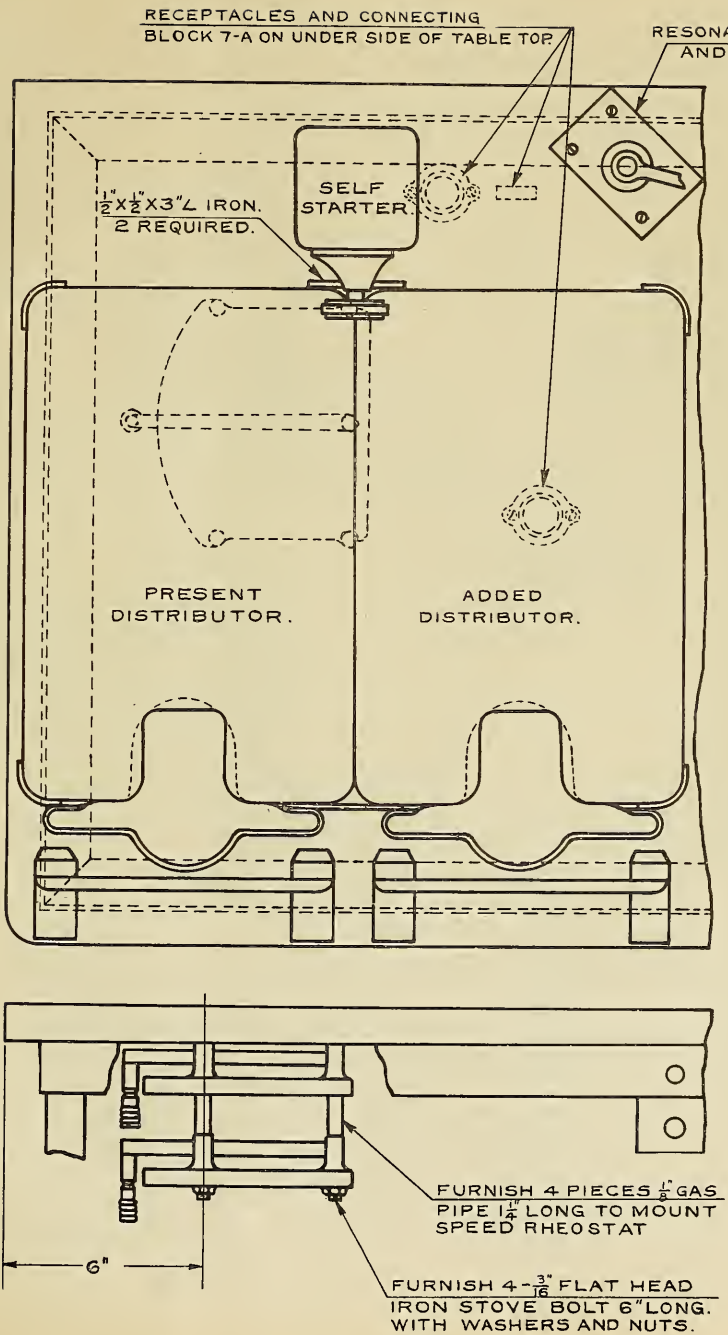

RECEPTACLES AND CONNECTING BLOCK 7-A ON UNDER SIDE OF TABLE TOP.
RESONATOR STAND AND BLOCK.
SELF STARTER.
1"X1/2"X3"L IRON. 2 REQUIRED.
PRESENT DISTRIBUTOR.
ADDED DISTRIBUTOR.
FURNISH 4 PIECES 1/8" GAS PIPE 1 1/4" LONG TO MOUNT SPEED RHEOSTAT
6"
FURNISH 4-3/16" FLAT HEAD IRON STOVE BOLT 6" LONG. WITH WASHERS AND NUTS.

Fig. 21

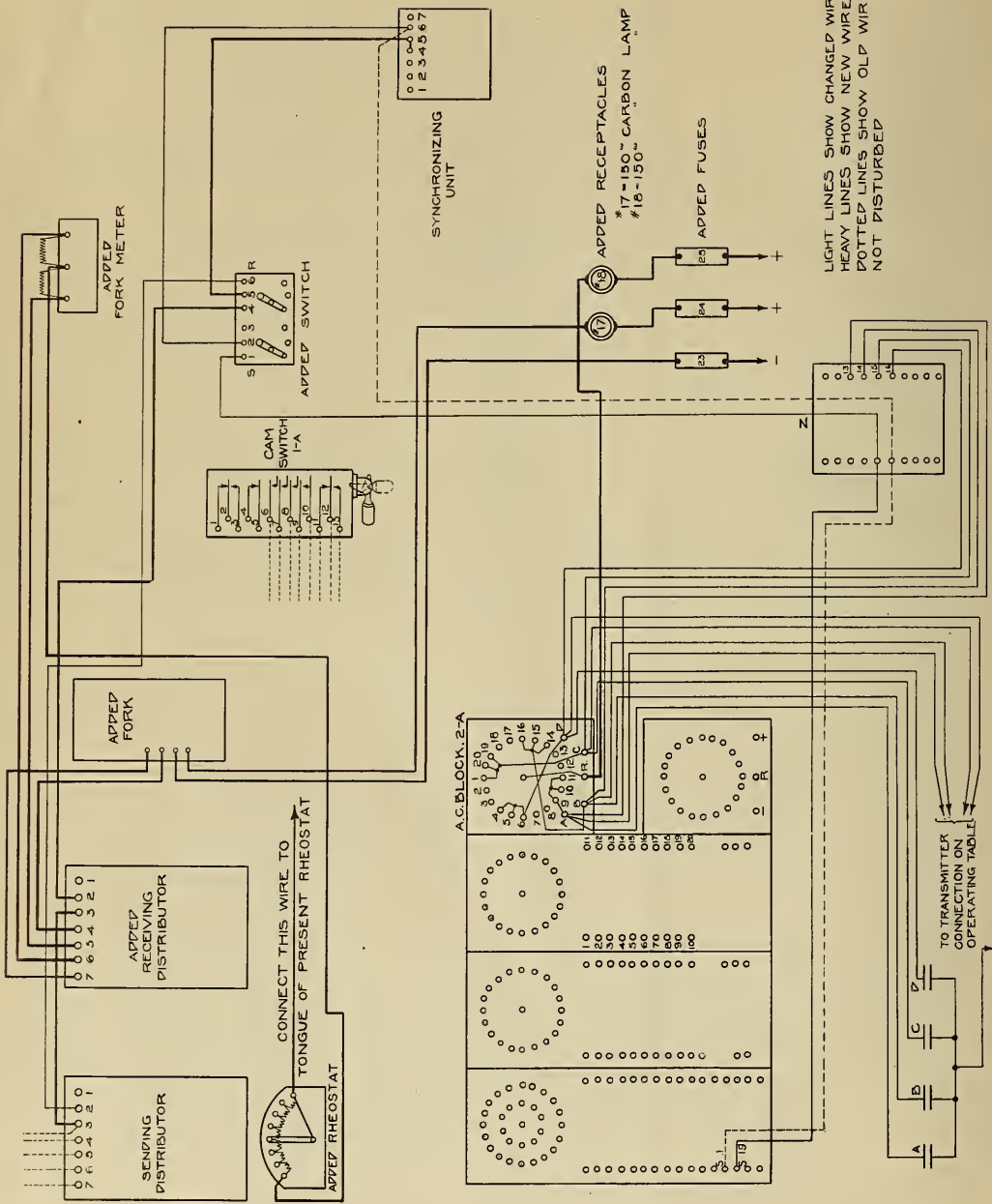

ADDED FORK METER
ADDED SWITCH
SYNCHRONIZING UNIT
ADDED RECEPTACLES
*17 - 150~ CARBON LAMP
#18 - 150~
ADDED FUSES
LIGHT LINES SHOW CHANGED WIRES
HEAVY LINES SHOW NEW WIRES
DOTTED LINES SHOW OLD WIRES
NOT DISTURBED
CAM SWITCH 1-A
ADDED FORK
ADDED RECEIVING DISTRIBUTOR
SENDING DISTRIBUTOR
CONNECT THIS WIRE TO TONGUE OF PRESENT RHEOSTAT
ADDED RHEOSTAT
A.C. BLOCK 2-A
TO TRANSMITTER CONNECTION ON OPERATING TABLE

Fig. 22

**42.** The following new wiring must be added:

a. Connect added fuse No. 23 to right hand back post of 110 volt switch.

b. Connect added fuses No. 24 and No. 25 to right hand front post of 110 volt switch.

c. The added distributor, distributor rheostat, fork, and fork meter call for new wiring, no changes in the original wiring being involved. Figure 22 shows the wiring of this added apparatus wiring.

**43.** The following apparatus and material is required for converting a single to a two distributor set:

1—Distributor and Face Plate.

1—Driving Fork 1-C.

1—Distributor Guard.

2—Angle Iron Stops for Distributor.

1—Balancing Block 2-A.

1—Diff rential Mil-Ammeter 1-A with Shunts.

1—Distributor Motor Rheostat (Ward Leonard Speed Controller Type 21.3-120 ohms).

1—6-Point Switch 4-A.

2—Cleat Receptacles 1-A.

3—Fuse Blocks 10-A.

1—Fuse 57-A (1 Ampere).

2—Fuse 57-A (3 Ampere).

2—Meter Supports 1-A.

2—Resistance Lamps 150 Ohms.

**44.** The two distributor four channel set may be converted into a three, two, or single channel set in exactly the same manner as the single distributor set. The method of balancing, checking speed, etc., is also identical with that described for single distributor sets, except that when correction is sent for checking speed or for getting the sets in synchronism both terminals usually send correction at the same time and both are therefore able to check the speed and ultimately put their respective receiving distributors in synchronism with the distant station's sending distributor simultaneously. While correction is being sent and synchronism established the cam switch and the S switch are both thrown to the right. When one of the terminals has obtained synchronism for his receiving distributor he throws his S switch to the left. He then signals the distant station that he is in synchronism by throwing his cam switch to the left for a moment and then throwing it back to the right again. During the short period that the cam switch was to the left reversals were sent out. The Automatic Chief at the distant station would immediately notice this by the operation of the main line meter, his printers or his sounder. When the cam switch is thrown to the right again the distant station finishes the operation of getting in step. When his set is in he throws his S and cam switches to the left. The station that first established synchronism then receives reversals which notifies him that the other station is also in step. He therefore closes his cam switch by throwing it to the normal left hand position. The sets are then ready for taking a range in exactly the same manner as that described for the single distributor set.

**45.** All multiplex sets are designed primarily for grounded circuit operation; i. e., that they are intended for use with only one line conductor, the ground or earth being

used as the return path for the current flowing in the line. This is usually a very satisfactory way to operate, but there are conditions that sometimes interfere and make it difficult, if not impossible, to operate on a grounded line.

46. The most difficult of these conditions to overcome is that commonly known as earth currents. When these currents are encountered the potential of the ground connection may not be the same at both terminals of a circuit and the line therefore appears to be biased. The value of the received current on the spacing side may differ from the received current on the marking side by as much as or even more than the normal value of the received current.

47. The only wholly satisfactory way to overcome this condition is to use two line conductors for the circuit and entirely disconnect the sets from the ground. Sets so operated are called metallic circuit sets.

48. To change a regular multiplex set so that it may be worked either as a grounded or metallic circuit set requires the addition of a three pole, double throw, knife switch shown by dotted lines on Figures 5 and 17 and an added retardation resistance box shown by dotted lines on Figures 2 and 15.

49. The wiring changes required are as follows:

a. Remove the wire connected to the center back terminal of the line battery switch and connect it to the center back terminal of the pole switch.

b. Remove the wire connected to the center front terminal of the line battery switch and connect it to the center center terminal on the 3 pole switch.

c. Remove the ground wire on posts 8 and 9 of the "Z" block and connect this wire to the left front terminal of the 3 pole switch.

d. Connect the left back terminal of the 3 pole switch with the center back terminal of the line battery switch.

e. Connect the left center terminals of the 3 pole switch with the center front terminal of the line battery switch.

f. Connect the center front terminal of the 3 pole switch with posts 8 and 9 of the "Z" block.

g. Connect the added line conductor through the line connector block to the right front terminal of the 3 pole switch.

h. Connect the negative terminal of a set of metallic circuit generators to the right back terminal of the 3 pole switch.

i. Connect the positive terminal of the metallic circuit generator set to the right center the terminal of the 3 pole switch.

j. Connect the common return of the metallic circuit generators to the right front terminal of the 3 pole switch.

k. Remove the three wires on the condenser terminals of the radial arm rheostat and connect them to the three corresponding terminals on the front of the added retardation resistance box.

l. Connect the three terminals on the back of the added retardation resistance box to the corresponding terminals on the radial arm rheostat.

These changes are shown in Figure 23.

m. All wiring changes except those mentioned in k and l are shown in Figure 23.

50. The following apparatus is required:

1 Trumbull Three-Pole Double Throw Battery Switch No. 712.

1 Retardation Resistance Box 1-A.

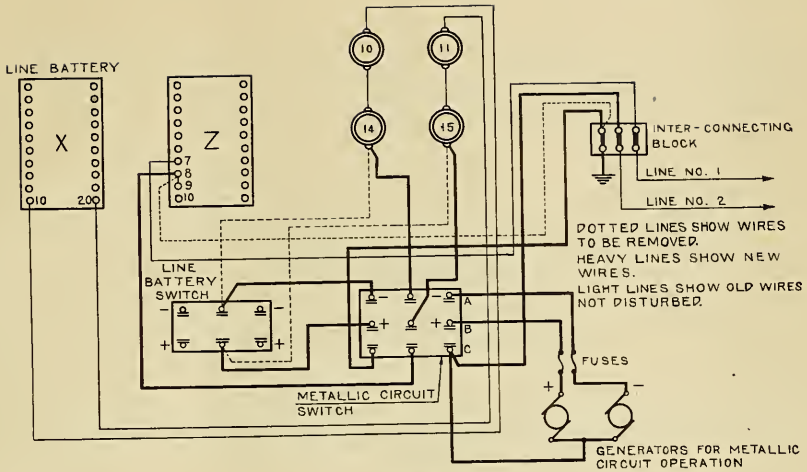



Fig. 23

**51.** A set modified as described in the preceding paragraphs may be operated in the usual manner as a regular grounded circuit terminal when the 3 pole switch is thrown to the left. If earth currents or some other cause should make it advisable to operate the set metallic, the 3 pole switch is thrown to the right, the second line conductor is connected to the set at the switchboard and the metallic circuit generators are started. The circuit is then balanced in the regular manner. The added retardation resistance box was added because the retardation resistance in the radial arm rheostat is usually not sufficient to properly balance metallic circuits and it may be necessary to use both sets of resistance to obtain a proper balance. After a balance is obtained the sets are started in the usual manner.

# The Western Union Telegraph Company

SPECIFICATIONS

FOR THE

## MULTIPLEX PRINTING TELEGRAPH SYSTEM

SECTION 8

## TEST AND SCHOOL TABLES

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These Specifications are the property of the Western Union Telegraph Company and shall not be published.

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CONTENTS


| Subject | Paragraph |
|---|---|
| TEST SETS | 1 |
| TEST DISTRIBUTOR | 2 |
| OPERATION | 3 |
| TESTING THE SPACING SIDE OF TRANSMITTERS | 4 |
| SCHOOL SETS | 5 |
| INTERCONNECTED SCHOOL TABLES | 6 |

SPECIFICATIONS INCLUDED: None.

PHOTOGRAPHS AND DRAWINGS:

| Figure No. | Drawing No. | Title |
|---|---|---|
| 1 | Photograph | Test Table. |
| 2 | Photograph | Test Distributor. |
| 3 | 22445- -1 | Test Table Layout |
| 4 | 22446- -1 | Theoretical Wiring Diagram. |
| 5 | 22447- -2 | Test Table Wiring Diagram. |
| 6 | 22448- -2 | Test Distributor Wiring Diagram. |
| 7 | 21722- -2 | Operating Table 4-A Wiring Diagram. |
| 8 | 22449- -1 | School Table Layout. |
| 9 | 10677- -2 | Method of interconnecting two 4-A School Tables. |

Fig. 1

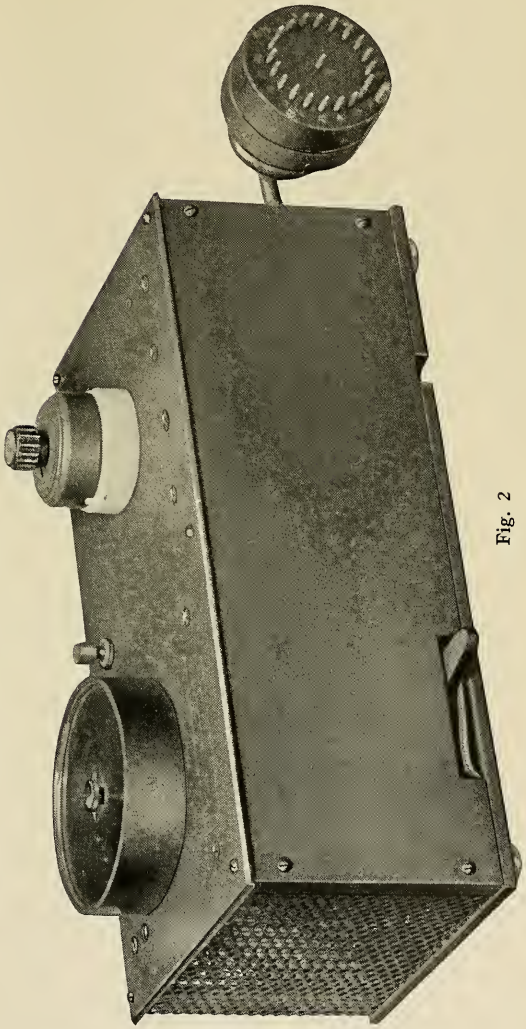
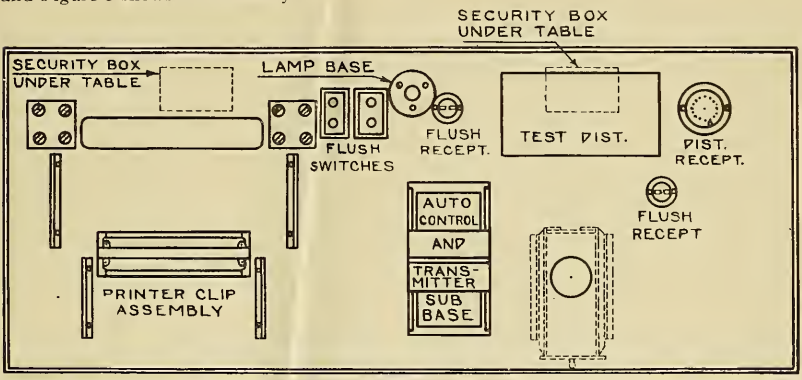


Fig. 2

## MULTIPLEX TEST AND SCHOOL SETS

1. **Test Sets.** For convenience in testing transmitters, auto controls, and printers, as well as to provide a convenient worktable for repairing and overhauling all multiplex apparatus, and afford also a place for keeping spare equipment ready for immediate service, test sets are provided (Fig. 1). These sets are built on tables similar in size and general plan to regular operating tables. They are provided with a set of drawers that may be used for tools, specifications, etc. Usually the test sets are placed next to and in line with a distributor table, but they may be placed at any convenient point where 110 volt potentials are available. Figure 1 shows the test table fully equipped, and Figure 3 shows the table layout.



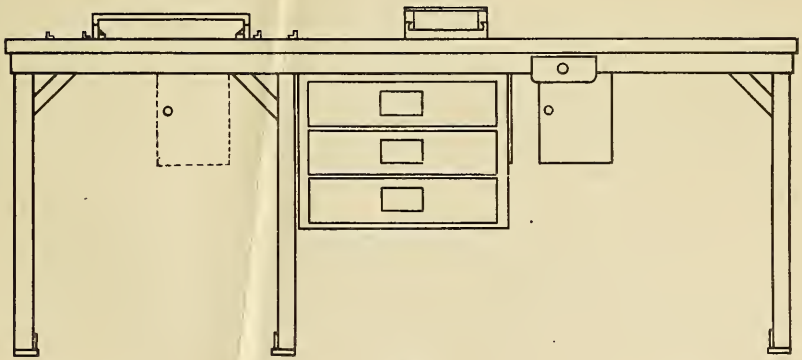



Fig. 3

2. The test set requires one piece of apparatus, not mentioned before in these specifications, called a test distributor (Fig. 2). It is a very simple form of distributor driven by a 110 volt DC. motor, the shaft of which is connected through a variable speed friction drive to a vertical shaft which carries one set of brushes. Only two rings are used, both of which are segmented.

3. When the test set is operated, positive impulses are sent from the marking contacts of the transmitter to the corresponding segments on the inside ring on the distributor, thence through the brushes to the segments on the outside ring which are connected to the printer selecting magnets and the pilot lamp. Local impulses for operating the printer sixth pulse magnet and the transmitter operating magnet are sent from positive battery connected to two segments on the inside ring immediately following the selecting through the brushes to the printer operating magnet segment and transmitter operating magnet segment respectively. These circuits may readily be traced on theoretical diagram shown in Figure 4 and also on the actual wiring diagrams of the test table and test distributor shown in Figures 5 and 6.

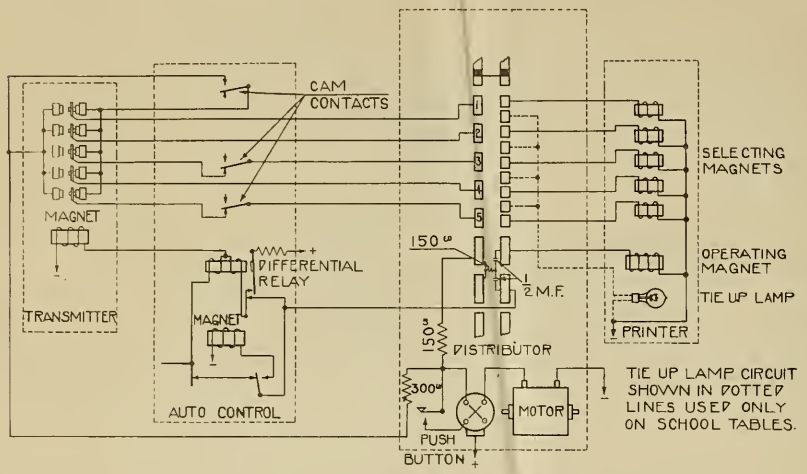



Fig. 4

4. If the auto control is operated the selection is set up in exactly the same way except that the battery connected to the distributor sending segments is determined by the auto control as already described in Section 6. Attention is called to the fact that on the test sets no actual impulses are sent from the spacing side of the transmitter, except when the auto control is operated. Whenever transmitters are tested, therefore, the auto control should be operated to make certain that the spacing side connections are intact.

5. **School Sets.** In order to provide operating positions where student Multiplex operators may be instructed in the actual handling of messages, school sets are available. These sets are standard operating tables, fully equipped with perforators, transmitters, auto controls, and printers, as well as the auxiliary equipment such as time stamps, numbering stamps, etc., to which have been added a test distributor. The operation of the sets is exactly the same as that described for test sets. Figure 7 is a wiring diagram of the school table, and Figure 8 shows the layout of the apparatus.

6. In certain offices it has been found advantageous to interconnect two school tables, so that the transmitter on one table sends to the printer on the second table, and vice versa. With this arrangement the student operators can be trained under conditions that are identical with the conditions actually met with in Multiplex operation. This interconnection is made possible by the addition of two test distributor plug sockets to each table in the positions shown in Figure 8 and wired as shown in Figure 9. On this drawing A and A′ represent the regular test distributor plug sockets, and B, B′,

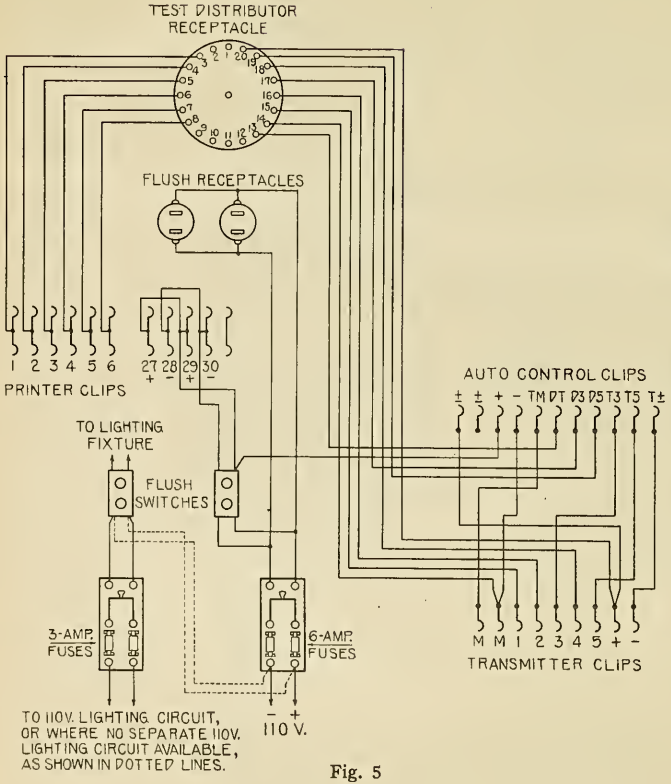

TEST DISTRIBUTOR
RECEPTACLE
FLUSH RECEPTACLES
1 2 3 4 5 6
27 28 29 30
PRINTER CLIPS
TO LIGHTING
FIXTURE
FLUSH
SWITCHES
AUTO CONTROL CLIPS
± ± + − TM DT D3 D5 T3 T5 T±
3-AMP.
FUSES
6-AMP.
FUSES
M M 1 2 3 4 5 + −
TRANSMITTER CLIPS
TO 110V. LIGHTING CIRCUIT,
OR WHERE NO SEPARATE 110V.
LIGHTING CIRCUIT AVAILABLE,
AS SHOWN IN DOTTED LINES.
− +
110 V.

Fig. 5

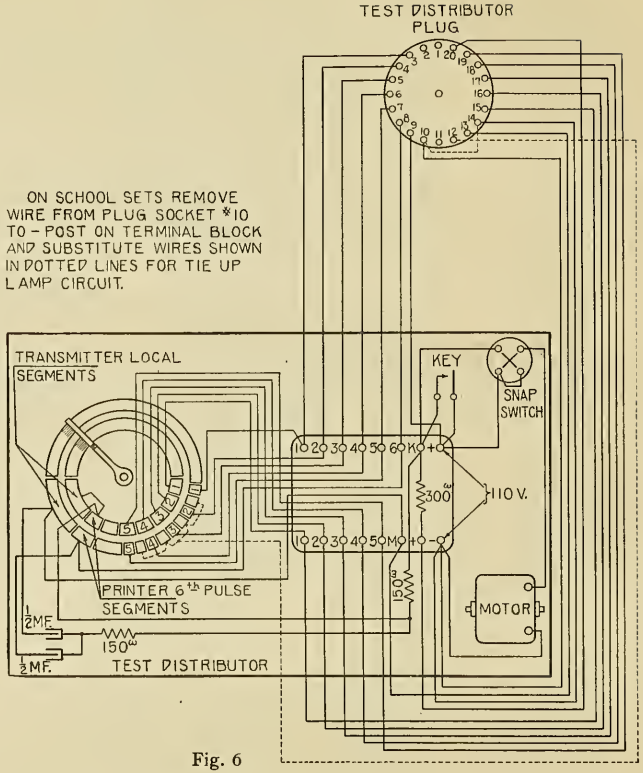

TEST DISTRIBUTOR
PLUG
ON SCHOOL SETS REMOVE
WIRE FROM PLUG SOCKET #10
TO − POST ON TERMINAL BLOCK
AND SUBSTITUTE WIRES SHOWN
IN DOTTED LINES FOR TIE UP
LAMP CIRCUIT.
TRANSMITTER LOCAL
SEGMENTS
KEY
SNAP
SWITCH
10 20 30 40 50 60 K0 +0 −
300Ω
110 V.
10 20 30 40 50 M0 +0 −
150Ω
MOTOR
PRINTER 6TH PULSE
SEGMENTS
½MF.
150Ω
½MF.
TEST DISTRIBUTOR

Fig. 6

C and C′ the added sockets. D and D′ are two test distributor plugs connected together as shown by a cable. This cable must, of course, be long enough to reach from one table to the other. To interconnect the two tables the test distributor plugs are moved from sockets A and A′ to B and B′ respectively and the plugs D and D′ are connected to sockets C and C′ respectively.

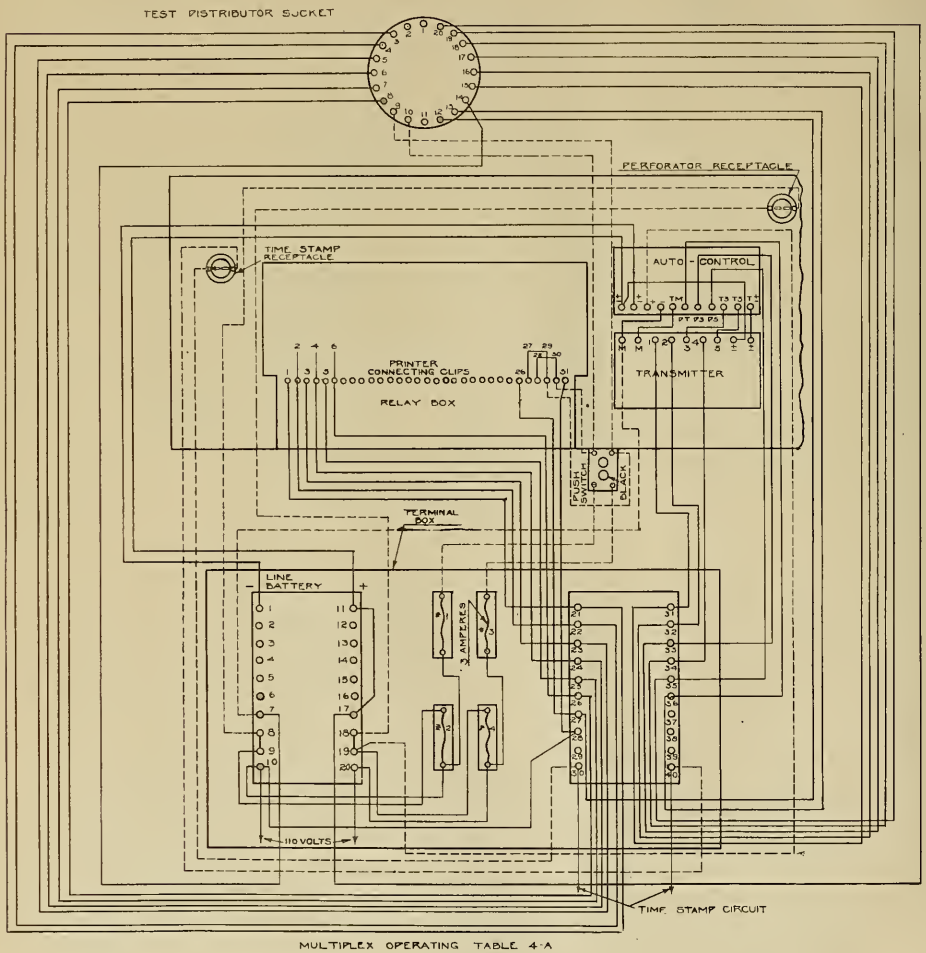



Fig. 7

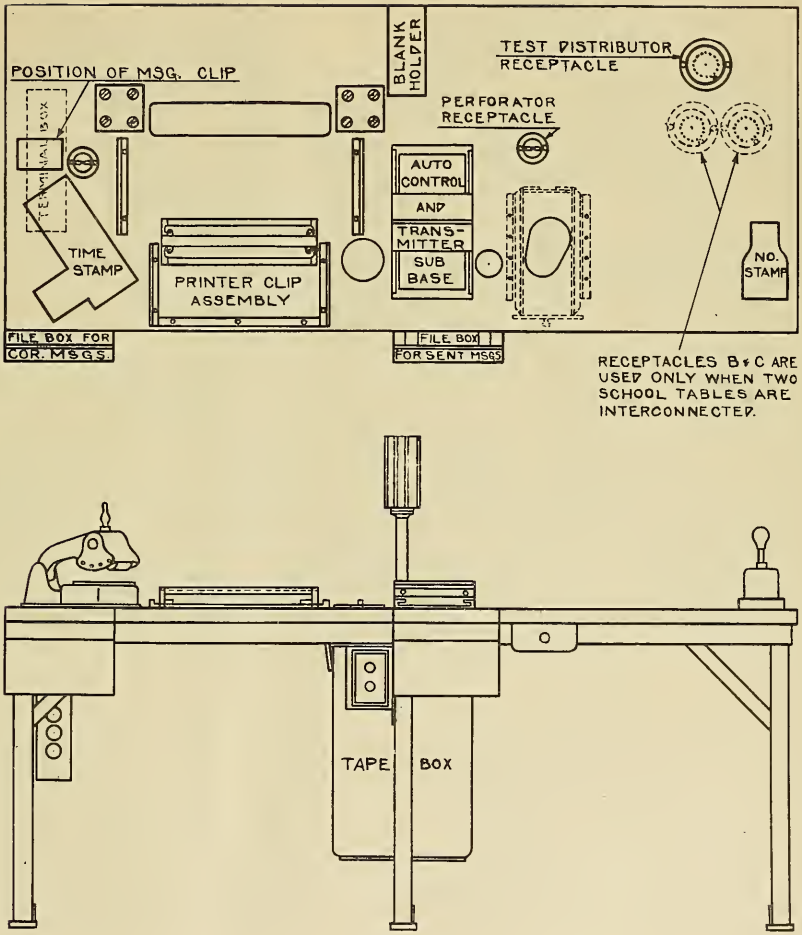

POSITION OF MSG. CLIP
BLANK HOLDER
TEST DISTRIBUTOR RECEPTACLE
PERFORATOR RECEPTACLE
TERMINAL BOX
AUTO CONTROL AND TRANS-MITTER SUB BASE
TIME STAMP
PRINTER CLIP ASSEMBLY
NO. STAMP
FILE BOX FOR COR. MSGS.
FILE BOX FOR SENT MSGS
RECEPTACLES B & C ARE USED ONLY WHEN TWO SCHOOL TABLES ARE INTERCONNECTED.
TAPE BOX

Fig. 8

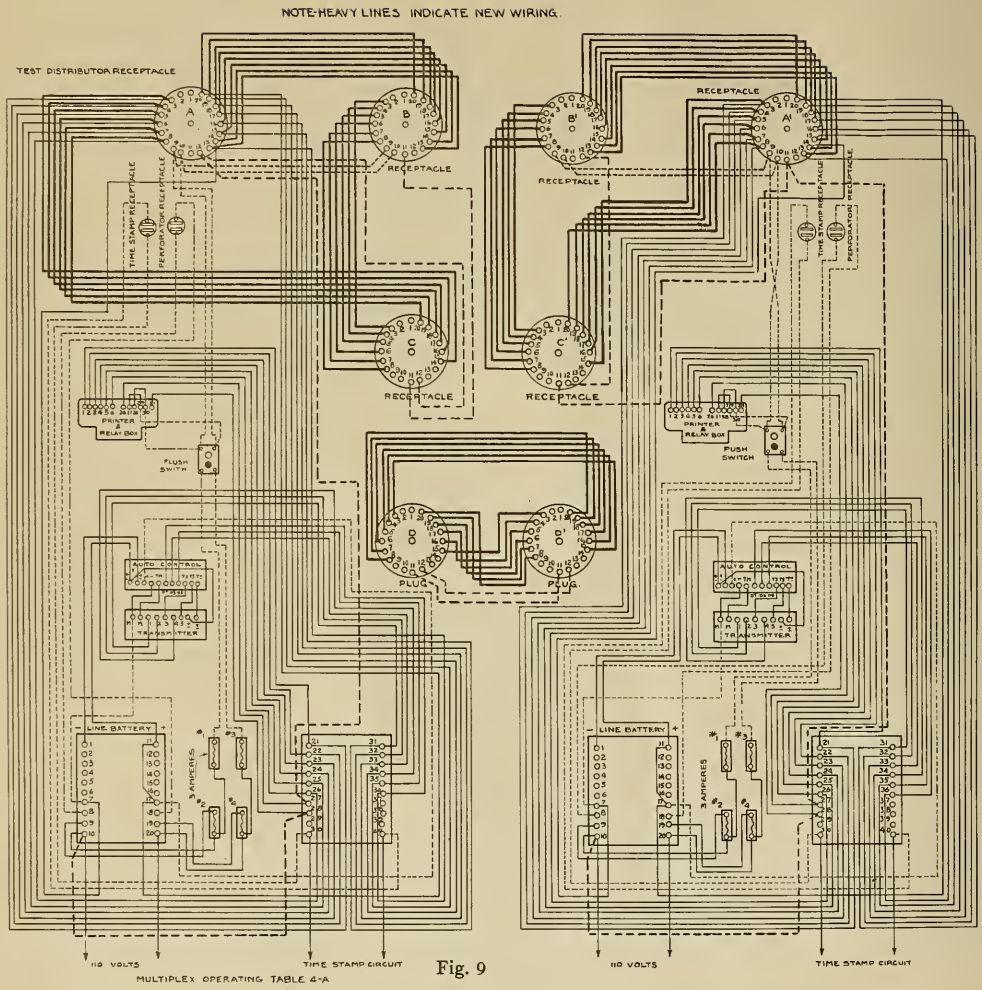

NOTE-HEAVY LINES INDICATE NEW WIRING.
TEST DISTRIBUTOR RECEPTACLE
RECEPTACLE
TIME STAMP RECEPTACLE
PERFORATOR RELAY RECEPTACLE
PRINTER & RELAY BOX
FLUSH SWITCH
PLUG
AUTO CONTROL
TRANSMITTER
LINE BATTERY
3 AMPERES
110 VOLTS
TIME STAMP CIRCUIT
MULTIPLEX OPERATING TABLE 4-A

Fig. 9

## ADJUSTMENTS

1. The test distributor shall be kept clean and oiled, motor bearing and gears properly packed with a good quality heavy oil such as the New York and New Jersey Lubricant Company's No. K-00 Special Non-Fluid Oil.

2. The leather friction wheel shall be replaced when it becomes eccentric, or when its surface becomes hard and glazed.

3. The brushes shall be carefully set so that the ends of both brushes rest on a line extending radially from the center of the vertical shaft.

## DATE DUE

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